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THROUGH THE EYES OF THE EDITOR

Luzerne G. Jordan has outlined the various factors to be considered in partial denture design. While he favors the use of fixed appliances or internal attachments, his analysis of the design of removable partial dentures with clasps is quite sound. The key to proper design is the proper distribution of occlusal forces.

Chastain G. Porter suggests that the technical procedures of denture construction should be simplified. He states that many of the complicated procedures are pseudoscientific, and that they tend to clutter and mash the factors which really are of importance. His evaluation of a procedure is based upon whether or not a step or procedure contributes to the function, comfort, appearance, or health of the patient. The technique he describes seems open to criticism on the basis of oversimplification at some points. Lined or fitted baseplates are more accurate than those he suggests. An adjustable articulator is of assistance in obtaining the tooth relations which are required to develop balanced occlusion which he agrees is desirable. The flat plane of occlusion may be satisfactory for closure in centric position, but it is likely to be more damaging to the supporting structures in eccentric closures than a properly balanced occlusion with cusp teeth. The correction of the occlusion in the mouth with a central bearing point tends to overcome this objection. His emphasis on the accomplishment of each step with accuracy is well placed.

Clyde H. Schuyler points out the responsibility of dentists in prosthetic service. Too many failures in this service are blamed on the patients when they are due to a lack of attention to detail or when too much responsibility is shifted elsewhere by the dentist. Special problems must be recognized by dentists, and they must be handled by dentists who know how to treat these special problems. The important consideration is that adequate treatment be given the patient. He states that the articulation of teeth is the most important phase of prosthetics. An accurate maxillomandibular relation record is essential. The most important consideration in establishing this record is a willingness on the part of the dentist to admit that the record may be incorrect, and a willingness to make the necessary checks to make sure that it is correct. He states that occlusion must be corrected after processing. This is quite true since our present denture bases do change as they are processed. He urges the selection and modification of posterior teeth to harmonize with the guiding factors of occlusion. He prefers to modify the so-called anatomic teeth, but the important consideration is that harmony of cusp inclines must be developed between each other and with the guiding factors of occlusion.

H. E. Denen discusses impressions for full dentures and describes a technique for the use of alginates for making the final impressions. He believes that pressure ap-

plied to tissues by the tray or impression material causes the destruction of tissues. He lists four requirements for an impression material which can hardly be criticized. He reports some research to prove that his opinions were correct. The objective of research should be to find out, and not to prove. The data presented indicate greater destruction of the ridges with "pressure" impressions than with "no-pressure" impressions. However, the data seem to be incomplete, especially as to the amount of pressure used. There are many unreported factors which may have been the cause of the failure of all "pressure" impression dentures within eighteen months. Not all of those who use "pressure" impressions have had this result. He states that the periphery of the denture is relatively unimportant because he believes atmospheric pressure is not a retentive force. This is, of course, contrary to the generally accepted concept of retention. No one denies the importance of a close adaptation of the denture to the tissue in its minute detail, but many gain the additional advantage of the pressure of the atmosphere against the exposed side of dentures when there is a good peripheral seal. He is quite right about the false retention of overextended dentures when he says they give temporary retention, but peripheries can be correctly formed to provide a peripheral seal which will assist the perfect adaptation of the dentures to the tissues in the retention of the dentures. When this is done correctly, the dentures may be retained by atmospheric pressure even after close adaptation to the tissues has been lost through shrinkage of the ridges. The technique he suggests probably does a better job of recording the peripheral tissues than he has indicated in his discussion.

Nina Simmonds has discussed nutrition as it relates to the prosthetic problem in such a way as to be interesting as well as valuable. She has used a hypothetical family to illustrate the effect of nutrition on the current dental needs in America. She calls attention to the importance of geriatrics and degenerative diseases which are of importance to prosthetists, and she suggests a diet which would serve to prevent much of our trouble. It seems logical to build right so it is not necessary to try to rebuild the skeleton.

Joseph S. Landa discusses the free-way space and its significance in the rehabilitation of the masticatory apparatus. He states that the biologic sciences have not received the attention they should have, and that relatively too much thought has been given to purely mechanical considerations. He points out the fact that measurements made on soft tissues are open to question, and that average measurements are in error under differing conditions. He suggests the term "interocclusal rest space" as being more significant and more accurate than the term "free-way space." This seems to be true. He used four methods for studying the interocclusal rest space to determine its constancy under varying conditions. He found considerable variation in the amount of interocclusal space which resulted from changes in position of the head or of the body. He makes a distinction between the "active" vertical dimension (the vertical dimensions of occlusion, the teeth in contact) and the "passive" vertical dimension (the vertical dimension of rest position, the teeth are separated and the mandible is suspended by the muscles in a state of tonic rest). The difference between these dimensions is the interocclusal rest space. It is simple designation which is easily understood and should be helpful to students of the problem. The conclusions he reaches seem sound.

Thure Brandrup-Wognsen discusses the movements and functional positions of the lower jaw, and describes an articulator which is based on the principles he establishes. He distinguishes between the "physiologic opening movement" and the "central opening movement." This seems to be logical in the light of present information. It could be the key to understanding some of the apparent differences of viewpoint regarding the "opening axis" of the jaw. His description of the "gliding" movement points out the possible changes in position of the rotation center in varying circumstances. He recognizes that the arcs of the Gothic arch tracing are affected by the amount of Bennett movement, and that the Hanau formula for adjusting the Hanau in-

strument for the Bennett movement has not been verified. The instrument which he has devised seems to be one in which the desirable features of several other instruments are used. The individual adjustment for the Bennett movement is good. The instrument seems to be sufficiently adjustable to accept lateral check bites, which the Hanau articulator will not do in many instances.

Harold M. Vernon has written a fine review of the present status of denture base materials. The list of desirable qualities of denture base materials is quite complete, and they should be kept in mind when new resins are offered to the profession for base materials. The resin chemistry which he describes is quite understandable. The possibility of the development of new resins for dentures is explored.

G. J. Perdigon points out the similarity of technique for fixed and removable restorations using reversible hydrocolloid. He feels that the hydrocolloid technique for fixed restorations would become more popular in the profession if this similarity was recognized. He suggests that the master cast be duplicated to obtain a working cast. Working casts obtained in this manner are one extra step removed from the original form in the mouth and may be less accurate. He treats the gum tissue at the gingival margins of cavity preparations according to its relation to the cavity margins. This seems sound. He includes directions for the laboratory procedures which should prove helpful in the necessary correlation of chair operations and laboratory operations. He emphasizes the importance of care and attention to detail in the technique.

Joseph E. Ewing has made an excellent classification of the modifications in jacket crown preparations for special situations. The modifications he suggests seem to be logical. They should be helpful in instances where the occlusion, the relations to adjoining teeth, or the condition of the tooth to be restored is not ideal.

Walter Wyrick suggests a method for restoring an anterior tooth when large interproximal spaces exist. While there may be objections on the basis of the lingual arm of the restoration, the esthetic results may be more important.

John B. Lazzari has described a simple and effective procedure for closing a traumatic opening in the hard palate.

James L. Armstrong tells how a successful dental clinic for the purposes of study was formed. He suggests a procedure by which study clubs can get assistance from educational agencies so they may help others while they help themselves.

—Carl O. Boucher

DESIGNING REMOVABLE PARTIAL DENTURES

With External Attachments (Clasps)

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WHEN considering the design of removable partial dentures we should not overlook the fact that many twelve- and fourteen-tooth fixed bridges have served to restore missing natural teeth for periods as long as twenty and thirty years, and some of these restorations were supported by only four and some by only three natural teeth.

Why did these bridges serve so long as dental restorations, such as they were? In my opinion it was due, at least in part, to the fact that the restoration itself was a rigid appliance, and when occlusal forces were applied at any point on the restoration they were distributed to all of the abutment teeth. Thus no single abutment tooth had to carry the entire occlusal load at any time. Such restorations did not, of course, present free-end extensions which would have exerted unreasonable leverages during masticatory function as do many removable partial dentures.

I have never seen a removable dental restoration, with clasp retainers, which has been worn for comparable periods of time. Tooth-borne removable restorations with *precision attachments* have rendered such service.

It is my opinion that (1) *Fixed bridges* are superior to any other type of partial denture restoration for those cases where they may be used advisedly. (2) Removal partial dentures with *precision attachments* are superior to any other form of removable partial denture for those cases where conditions permit their use. (3) Removable partial dentures with *external attachments* such as clasps should be used only for those cases where fixed bridges or precision type removable restorations could not be used advisedly.

DESIGN

The term "design," as used in removable partial denture construction, refers to the shape and structural details of the removable restoration.

Partial dentures should first be designed on study casts before any operative or restorative construction procedures are started for the patient, and especially before final impressions are made. This is important because an acceptable partial denture design for a given patient may necessitate special preparations on the abutment teeth, and in some cases the denture base areas may require re-shaping.

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INFLUENCING FACTORS

There are many factors presented by each individual patient which may influence partial denture design. Included in the following list are some of these factors:

Health of the patient
Condition of remaining natural teeth
Condition of osseous structures
Number of remaining natural teeth
Distribution in the arch of remaining natural teeth
Probable retention period of remaining natural teeth
Distribution and extent of edentulous areas
Condition of mucosa throughout the mouth and especially over edentulous areas
Form of edentulous areas
Relation of opposing arches
Nature of existing occlusion
Esthetics. The high and low lip lines or the extent to which teeth and gums show during function
Shape and contours of remaining natural teeth
Long axis inclination of abutment teeth in relation to other teeth in the same arch
Musculature of the human dental mechanism
Occlusal surface morphology of natural teeth
Extent of intermaxillary space at the accepted vertical dimension
Phonetics
Total support available for the partial denture
Economic factors may influence a choice of material and therefore the design. The patient's ability to pay may not be in keeping with the design of choice
Materials used in construction. If for any reason the choice of a material is limited, the design must be influenced by the inherent properties of material used
Patient's care of his own mouth

STRUCTURAL DETAILS

It is appropriate that we consider a few of the structural details which may contribute to the construction of a serviceable prosthesis. I have chosen to discuss this feature of partial denture design by making short statements which I have numbered for the purpose of reference and also to assure their separation. The numerical designations have no bearing upon the relative importance of the individual statements.

1. Balanced occlusion is essential to successful partial denture function. To make this feature possible, the remaining natural teeth must be placed in proper occlusal balance during preparation of the mouth and before final impression making. The occlusal surfaces of the prosthesis should be made to harmonize with those of the natural teeth.

2. Partial dentures should be rigidly constructed so that forces applied at any point on their occlusal surfaces will be distributed throughout the entire restoration, and thus be widely distributed to the supporting structures. The use of stress breakers, flexible lingual and palatal bars, and overly flexible clasp arms detracts from this possibility.

3. Occlusal forces should be properly distributed to the remaining natural teeth and to the mucosa.

Distribution to the natural teeth is accomplished by:

A. Proper occlusal rest seats and occlusal rests.
B. The use of rigid retainer (clasp) connectors.

C. Proper clasp arm design.

D. The use of continuous clasps.

E. Extending the denture base to contact the natural teeth.

F. The use of rigid base connectors (lingual and palatal bars).

Distribution to the mucosa is accomplished by:

A. The base or saddle design. Base areas should be increased when there is a decrease in the number and distribution of the natural teeth. Extensive edentulous areas suggest the use of bases which simulate complete denture base designs for such areas.

B. The use of rigid lingual and palatal bars.

C. Using properly shaped occlusal surfaces on the prosthesis.

4. Natural teeth which are to support occlusal rests should be provided with definite occlusal rest seats which will prevent the occlusal rests from sliding gingivally on the teeth, and also prevent the abutment teeth from being forced out of their proper position and alignment.

5. Occlusal rests should be strong enough to resist fracture. They should not be placed upon tooth surfaces which slope gingivally toward the edentulous area.

6. Phonetics. If bases or bars must be located in the anterior region of the palate they should be designed as delicately as possible, and should be made to harmonize with or restore natural contours in order that the speech habits of the patient may not be disturbed. Borders of bars or bases should be placed in depressions between the rugae.

7. The borders of the exposed portion of palatal bars should be shaped so that they depress the mucosa *slightly* when they are positioned in the mouth. This is accomplished by scraping the master cast, just within the bar outline, in a manner similar to making a post dam or a border dam, before making the palatal bar.

8. Lingual bars should not contact the mucosa when the partial denture is positioned in the mouth. This is especially true of free-end extension dentures.

9. Short edentulous spaces, with natural teeth at each extremity, should be restored with metal teeth which are constructed as a part of the metal framework. The buccal or labial surface of such teeth may be supplied with synthetic porcelain or a self-curing tooth-colored plastic resin material to improve esthetics.

The use of porcelain diatoric teeth in such areas is contraindicated because they, together with the metal framework, occupy so much of the small edentulous space that too little space remains for an adequate bulk of plastic base material to provide the necessary strength.

10. Tooth-colored materials such as inserts or facings should be used whenever esthetics would be improved.

11. A very narrow intermaxillary space (vertical space) suggests the use of metal occlusal surfaces, plastic teeth, or even the base material alone, instead of porcelain teeth, which, when they are made too thin by grinding, usually fracture under occlusal forces.

12. Base or saddle borders should not detract from esthetics. On upper dentures, the master cast should be scraped, if necessary, to assure intimate contact of base borders with the mucosa where such borders might show during speech or when smiling.

13. The use of artificial teeth of even greater gingival length than the adjacent natural teeth often improves the appearance of the partial denture in the mouth.

14. Stress breakers (nonrigid retainer connectors) should be used with caution. Their primary purpose is to decrease the occlusal load on the abutment teeth and thus divert it to the mucosa. In other words their use makes a denture mucosa borne.

Their application should be limited to use for those patients in whom very few natural teeth remain in the arch which are considered absolutely essential to the retention of the denture, such as for cleft palate patients, or where the endentulous ridge would offer no retention for a complete denture. They are sometimes indicated where a long distal extension is necessary on one side of the arch and the abutment tooth on that side would be overloaded if a rigid retainer connector was used.

15. Retainers should be designed so that they will all go to place easily after they have been assembled into one solid unit in the finished partial denture. This requires proper preparation of the mouth, based upon a careful survey of the study cast, and also upon proper survey and design of the prosthesis on the working casts.

16. Partial dentures should be made tooth borne whenever the condition, number, and distribution of the remaining natural teeth, together with their osseous support, will permit.

17. Partial denture bases should be made of a material which is conveniently and economically added to, as the need requires, by relining procedures. The plastic resins meet this requirement.

18. Partial denture bases should be designed to engage all possible base-supporting area. Many partial dentures fail to serve their intended purpose because their bases are too short and/or too narrow buccolingually. If metal bases are to be used, they should be designed to cover the same amount of mucosa-supporting area as would plastic material bases for the same case.

19. Partial denture retention (resistance against vertical displacement away from the ridge) is not a primary factor in design. It is secondary to a consideration of the health and preservation of the teeth and supporting tissues, to good occlusion, to the proper distribution of occlusal forces, to the comfort of the patient, to efficient masticatory function, and to esthetics.

20. The use of long flexible clasp arms suggests special occlusal rest preparations on the abutment teeth to assure proper horizontal occlusal force distribution to such teeth.

21. If missing anterior teeth are to be restored with the partial denture, rest seats should be made in metallic restorations on the adjacent natural teeth,

and proper occlusal rests should be constructed so this portion of the partial denture will be tooth borne.

22. If the maxillary base covers the palate, its posterior border should be positioned the same as for a complete denture, and it should be post dammed.

23. If a horseshoe design is used on the maxilla, the border next to the open palate should be border dammed the same as for a palatal bar, or the posterior border of a full upper denture. This is done in the presence of the patient, when the tissues can be carefully examined and palpated, the cast scraped, the temporary base plate readapted, and tried in the mouth.

24. Clasp arms of circumferential clasps should be properly tapered toward their free ends. Failure to do this often results in fracture of the clasp arm or in trauma to the abutment tooth, or both.

25. If clasps are to be placed on central or lateral incisors, these teeth should often be prepared to receive mesiodistal grip clasps. Such clasps will appear as gold restorations on the proximal surfaces of these teeth. They should not be used in connection with extensive free-end extension dentures because of the resulting leverage on the teeth.

26. Indirect retention is obtained by extending the partial denture design beyond the fulcrum line to prevent rotation of the prosthesis about this line.

27. Clasps should not grip the abutment teeth too firmly, especially on free-end extension dentures, because functional movement of the base or bases would exert a strain upon the abutment teeth which might cause their premature loss.

28. Stabilizing support may often be obtained by extending the metal framework across marginal ridges, or embrasures, onto buccal or labial areas of the natural teeth where they may appear as metallic restorations.

29. Partial dentures may be designed to stabilize loose natural teeth whose retention seems advisable. Loose lower incisors often become firm when they are stabilized by a continuous clasp which is used in conjunction with a partial lower denture.

30. Soft pendulous ridges offer poor support and retention to partial denture bases. In such situations, the remaining natural teeth should be utilized to supply more support and retention, through the framework design, than would be necessary for patients presenting prominent and well-formed edentulous areas.

31. Connectors on individual clasps should be positioned to avoid interference with the artificial teeth, and they should not be located in areas where the base material will be thin.

32. Unilateral partial dentures with external attachments only should not be constructed. A stabilizing bar should always extend to the opposite side of the dental arch to prevent rotation of the prosthesis on its occlusal rests.

33. The direction of insertion of a partial denture should, whenever possible, be parallel to the principal vertical occlusal forces which will be placed upon it during function.

34. Continuous clasps, when properly positioned, help to prevent horizontal displacement of a partial denture because they engage more than just the abutment teeth in its support. They may also aid in stabilizing natural teeth which, although slightly loose, are being retained.

Their use is especially indicated for partial lower distal extension designs. They also serve as indirect retainers by preventing movement of free-end extension bases away from the ridge.

35. In some dentures, the denture base itself may be shaped to contact the lingual surfaces of the natural teeth and thus serve the purpose of a continuous clasp. The contact of the base on the teeth should occur along the height of contour of the teeth as determined by the survey. Such base designs should never be delivered to the patient until the areas which would contact the tooth from 1 to 2 mm. gingivally to the height of contour, and the areas which would contact the free margin of the gum tissue (⅛ to ¼ inch) *have been generously relieved.* The narrow area which remains in contact with the natural teeth will be similar to a continuous clasp and should definitely not be altered during the trimming and polishing procedures.

36. The proper use of a surveying instrument during partial denture construction enhances the possibility of its being a successful dental restoration.

37. When properly used, a surveying instrument will reveal the answers to the following questions:

A. Do the remaining natural teeth present inclinations or contours which would interfere with proper construction of the partial denture?

B. Do the edentulous areas present undercuts which would interfere with the seating and removal of the base or bases of a finished partial denture?

C. Do the abutment teeth present desirable undercuts below their height of contour for clasp-arm retention, or will these teeth require special preparation before they will offer such retention areas?

D. Do the abutment teeth present a height of contour at, or very close to, their occlusal surfaces where clasp arms would be positioned? Such teeth would require reshaping.

E. Where is the height of contour of each abutment tooth? This is determined, of course, by the direction chosen for the insertion of the restoration.

F. How far gingivally to the height of contour should the clasp arms be located? The answer will, of course, depend upon the angle formed between the side of the tooth and the vertical scriber of the surveyor.

G. Should the proximal surfaces of the abutment teeth be reduced by grinding or by restorations to avoid extensive triangular pockets between the teeth and the partial denture?

H. How should individual restorations on the abutment teeth be shaped so that they will present the proper inclinations and contours to meet the requirements of the future partial denture?

I. Will it be possible to use a labial surface saddle when supplying missing anterior teeth on a ridge that is deeply undercut above or below its crest?

38. Casts should be positioned in the surveying instrument so that the occlusal plane of the teeth, already present on the cast or to be supplied, will be at right angles to the vertical post of the surveyor. Slight deviations from this position are acceptable, but extensive tilting of the cast in the surveyor is detrimental.

39. If extensive tilting of the cast is necessary to obtain retention areas for clasp arms, or for other reasons, it is evidence that the operator did not properly prepare the mouth previous to final impression making. It is difficult to imagine that a construction engineer would erect a fine structure without first preparing the most important part—the foundation.

A PLAN FOR DESIGNING PARTIAL DENTURES

I find that the designing of partial dentures is a reasonably simple procedure when it is based upon the distribution of each of the principal occlusal forces which will be placed upon the prosthesis during function.

Vertical occlusal forces are distributed to the natural teeth by means of occlusal rests, rigid retainer connectors, and to the mucosa by means of properly designed bases and rigid base connectors.

Lateral occlusal forces are distributed to the natural teeth by the occlusal rest design, clasp arms if of proper rigidity, by continuous clasps or their equivalent (base-contacting teeth), by rigid retainer connectors, and to the mucosa by means of proper base design and rigid base connectors when used.

Anteroposterior occlusal forces are directed to the natural teeth by means of occlusal rest design, body of the clasps, clasp arms, continuous clasps, base design when contacting the teeth, and to the mucosa by the base design.

The details of application of all of these features must, of course, be influenced by the problems presented by the individual patient, but the solution becomes a comparatively simple matter after the fundamental design has been established as described.

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SIMPLICITY VERSUS COMPLEXITY

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"Nothing is more simple than greatness, indeed to be simple is to be great."—
Ralph Waldo Emerson.

COMPLETE denture prosthesis provides an important health service to a large segment of civilized humanity. Many varied concepts, or schools of thought, exist regarding the best procedure to use in supplying this service. While uniformity or standardization of methods is neither expected nor advocated, it is emphatically believed that the objectives of this project may be better achieved by a greater simplification of technical procedures. To do a good job in a concise manner, neglecting nothing of value yet eliminating all useless falderal, should merit the approbation of all concerned. The denture prosthetist need not assume the aura of a superscientist in order to perform this task. In fact many pseudoscientific procedures have infiltrated denture construction during its evolutionary development. Such procedures only serve to clutter and mask the importance of factors which really are of major consequence. The criterion of any step in denture construction should be: Does it contribute to the function, comfort, appearance, or health of the patient? If the answer is negative, it may well be omitted.

How may the wheat be separated from the chaff? How may we rid ourselves of the myriad of complexities which threaten to overshadow the thorough execution of steps which really do contribute something of essential value? This may be accomplished only by an unprejudiced revision of thought based upon a careful evaluation of the various concepts of denture construction. A brief discussion of the salient factors involved might serve as a catalyst to stimulate some reactionary change.

IMPRESSIONS

Impressions are best made with a combination of an individual tray and a corrective or finishing material. Properly contoured and extended trays contribute much to the design of the finished dentures. The contour and extension must be in accord with the anatomy and physiology of the individual patient. Important as the tray may be, it serves only as a vehicle to convey some plastic substance into close apposition with the tissues, and to support it upon its removal from the mouth. The material of the tray is, therefore, of only transitory import-

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ance. Trays fashioned of high heat impression compound are as good as those more laboriously made. Such compound trays, removed from the metal stock trays, reduced in bulk by knife trimming, "muscle-trimmed," and "spaced" to avoid undesirable pressures, are entirely adequate. Some operators may prefer trays made of baseplate material or of autocuring resin. These materials contribute nothing except additional strength which is of some advantage in the mandibular tray.

The foundation tissues should be recorded in their passive, undistorted state. The border structures must be registered in accordance with their physiologic tolerance. Some material should be chosen which is least unpleasant to the patient and most acceptable to the dentist. An alginate or a zinc oxide-eugenol paste is suitable for this purpose. The finished impressions should portray maximum tissue coverage in harmony with function, and should form a foundation for support of the contiguous facial structures.

This procedure comprises a simple yet adequate impression technique. It is unsurpassed by more elaborate and time-consuming methods. It may be accomplished in one patient visit, if desired.

CASTS AND OCCLUSION RIMS

Good casts, upon which to build, are important. All data recorded in the impressions must be preserved. This requires careful boxing which also insures better condensation by vibration, and a definite limitation of the size of the bases. Time spent in boxing expedites later steps such as trimming, mounting, flasking, and remounting for correction of dimensional change after processing. Casts should be indexed for this purpose.

Baseplates must be well adapted, but intimate fitting into undercut areas should be avoided. The simple thermoplastic shellac baseplate is adequate, provided care is taken to prevent warpage during the subsequent steps. Resinous bases may be used, but care must be exercised not to mutilate the casts upon their removal. Use of so-called stabilized bases lined with a paste is undesirable, unnecessary, and withal a very untidy procedure.

Wax rims should be formed to simulate the position and contour which will later be assumed by the anterior teeth. A simple central bearing device should be attached parallel to the posterior ridge areas. It is not necessary to secure a tentative centric relation record and to mount the casts on an articulator for positioning this device as is so often done. With a little experience and judgment, this time-consuming step may be eliminated.

JAW RELATION

Jaw relation may be divided, for study, into its two components, vertical and centric. The vertical jaw relation is not a mechanically precise position. True, as first emphasized by Niswonger,[1] it must be registered within a limited functional range allowing adequate provision for about 3 mm. of free-way space in the incisor region. Equally as important as its registration is its maintenance, over the years, within this functional range. Osseous changes should be minimized by maximum

basal coverage, and by development of the least destructive type of occlusion possible.

Pre-extraction data should be utilized if available. A study of the patient's face, the rest position, free-way space, and parallelism of the ridges should be made. These factors constitute the basis of determination of proper vertical jaw relation. Mechanical measuring devices may serve as helpful adjuncts. Whether these measure in pounds of pressure or in millimeters, they should be considered only as auxiliary aids. The judgment of the prosthetist should be the final deciding influence.

Centric relation is unique in that its registration is the one and only mechanical step in denture construction. While some "systems"[2] rely on mechanical appliances for most of the decisions involved, it is believed that centric registration is the only step in which a mechanical contrivance should take precedence over the judgment of the dentist. The apex of the Gothic arch or needle-point tracing should be accepted as a starting point from which to build an occlusion. Such terms as "functional centric" or "acquired centric" are misnomers and should be deleted. Any jaw-relation other than that of the Gothic arch apex is an eccentric jaw relation.

Centric relation should be registered with a device capable of scribing the Gothic arch tracing, and stabilized with an intraoral central bearing point. A plaster check bite should be made to secure the occlusion rims in the determined vertical and true centric relation. This is the simplest and most accurate known method of securing the jaws in their correct, unstrained positional relationship.

The individual operator must decide whether protrusive or lateral check bites will aid him in his quest for balanced occlusion. Their use is not essential, nor even desirable, in the construction of dentures of the highest type of efficiency.

THE ARTICULATOR

Jaw relation is preserved on some sort of hinged mechanism which should be regarded merely as a convenience to aid in setting the teeth. Inasmuch as no articulator can reproduce all of the mandibular gyrations of mastication, the procedure may now well be divested of most of the futile complexities which have muddled denture construction for the past one-half century. The conception of reproduction of gliding excursions should be abandoned for two reasons. First, it is impossible of attainment due to tissue resiliency both in the joint and under the bases. Second, it is of only slight value as these excursive movements are not used in chewing. The concept of cusps making precise contacts in balancing and working positions as guided by condylar paths is a fallacy. The bolus, as shown by Jankelson,[3] is fairly well macerated before the teeth are even in contact for the final few strokes just before swallowing. Chewing is done by functional cycles as conclusively proved by Kurth's[4] stroboscopic photographs and Boswell's[5] mandibulographs. The entire cycle can never be so much as feebly approximated by any articulator, even though it may be adjusted to imitate some of the relatively unimportant components of mastication. Owen[6] has shown that, even if reproduced, the influence of condyle guidance is practically nil at the working points,

the teeth. This preponderance of sound evidence should prove conclusively that it is futile to strive long hours in a vain attempt to regulate a metallic device to simulate jaw movements.

The casts are mounted, without benefit of the face-bow, on any substantial articulator capable of opening and closing accurately. Since there is no attempt to imitate jaw movements the hinge axis is of no importance. A simplex or arbitrary type of instrument is entirely adequate. If eccentric check bites have been made, an articulator capable of sagittal path adjustment may be used. This procedure may be helpful to some operators.

The foregoing discussion does not imply that balance is not desirable in denture occlusion even though it is not used very much in actual mastication. Balance is of greater importance during the twenty-two hours of the day and night when no food is in the mouth. The old saw, generally accredited to Prime, "Enter bolus, exit balance," is one of the most succinct statements ever uttered.

ANTERIOR TEETH. ESTHETICS

Esthetics, a sadly neglected phase of denture construction, is based on many correlated factors, one of which has been discussed under vertical relation. A natural cranial positioning of the anterior teeth is of primary importance. This is followed in importance by a pleasing shade, size, and mold or form. The use of mechanical gadgets to select teeth can only produce stereotyped effects and should be avoided. The same is true of reliance on charts and average measurements. In fact, there is little scientific evidence to justify anterior tooth selection according to the patient's face form. An esthetic sense should be developed, and a freedom from all binding rules should be cultivated.

Individual modification and characterization of the anterior teeth should be employed extensively. These measures may be imparted to stock teeth or incorporated in teeth made in the dental office. A mixing of various shades and molds is often advisable. Bicuspid teeth play a more important role than is usually recognized. Characteristic arrangement and irregularities contribute greatly to natural appearance. In the absence of pre-extraction data, arch form and old photographs are reliable guides. Immediate replacement of teeth should be extensively practiced, thus simplifying the problem by supplanting the need for deduction as to what kind of teeth to use and where to set them. Even though correct axial alignment provides the principal support for the lips and cheeks, buccal and labial contours should not be overlooked. Phonetic factors are, fortunately, nearly always interacting with good esthetic tooth positioning and contouring, and are seldom a problem. It is not believed that carving and festooning play a critical part in producing better enunciation and speech.

POSTERIOR TOOTH FORM. OCCLUSION

An occlusion must be developed which will function most efficiently and with the least amount of trauma to the supporting structures. Complete denture occlusion should function in excursive movement only in the horizontal plane or

in two dimensions. These two dimensions may be visualized as length, or protrusion, and width, or lateral excursions. The third dimension, height, as introduced by cusp teeth, should never be incorporated to complicate the problem for both patient and dentist. Cuspal elevations tend to create occlusal trauma by a constant shifting of the bases upon the underlying tissues. Three-dimensional occlusion using cusp teeth can be perfected only by exacting and relatively complex techniques such as the Meyer[7] or Stansbery[8] methods. Even though a perfection of excursive occlusion may be accomplished by such procedures, it cannot be maintained during the progressive vertical closure which occurs as dentures are worn. These considerations definitely rule out the use of cusp teeth.

Only flat cuspless teeth possessing sharp cutting ridges, a minimum of occlusal contact, and free escapeways for food are applicable to this simpler concept of denture construction. The buccal segment of the lower teeth should be designed as a subocclusal element as advocated by Sears.[9] This type of tooth directs occlusal forces to the lingual side of the ridge crest and greatly lessens the magnitude of traumatic forces.

Denture teeth, both anterior and posterior, are best fabricated of durable, chemical resistant plastic material. It is undeniable that plastic teeth have shown wear, sometimes excessive, just as porcelain teeth have sometimes exhibited excessive breakage. While improvement is yet to be desired, plastic teeth are now available which will serve during the useful life of the dentures. Plastic teeth reduce traumatic impacts and clatter, and are much more acceptable to a majority of patients than porcelain teeth.

Posterior teeth should be cutters, not mashers, of food. The metallic inserts imbedded in plastic teeth as designed by Hardy[10] are unquestionably the acme of efficiency and durability. Their sharpness lessens traumatic pressure to the ridges which should compensate for their extreme hardness. They possess esthetic limitations which preclude their use in some instances. This may be obviated by substituting all plastic teeth for the first bicuspids if they are conspicuous. Porcelain is too friable a material to employ, if sharp cutting ridges are desired.

Just as cusp teeth constitute a disturbing and traumatic influence, so does the setting of teeth to a compensating curve which acts, in effect, as one large cuspal incline. A flat plane arrangement of the bicuspids and first molars, paralleling the occlusal plane to the stress bearing portions of both ridges, is of a paramount importance. No contact of anterior teeth nor of second molars should be permitted in centric relation. This type of occlusion, as proposed by Sears,[11] produces a centralization of occlusal forces which contributes greatly to stability during both masticatory cycles and excursive movement. The lower second molars should incline upward, distally, at an angle of about 30 degrees to the occlusal plane, to provide balancing elements or ramps. This angulation must be modified, if necessary, at the time of try-in. It is best to leave a little too much steepness of the ramps to insure sufficient material at the time of the grind-in of the finished dentures. Upper second molars may be omitted if the tuberosities closely approximate the retromolar pads. If included, they should be elevated and inclined out of occlusal contact.

Protrusive and lateral excursions may permit a bare contact of the incisal edges simultaneously with a firm contact of the lower second molar ramps against the distal portion of the upper first molars. These positions are, of course, seldom if ever assumed in chewing. Such a balance does, however, stabilize and provide a means of reseating the bases, if and when they start to loosen.

This type of tooth arrangement and occlusion is believed to be the most efficient and nontraumatic possible. It will adjust itself to slight vertical closure which inevitably occurs. According to Kurth,[12] the occlusal problem is simplified by two-thirds if a cuspless, flat plane, two-dimensional occlusion is developed.

THE DENTURE BASE MATERIAL

The waxed dentures should be perpetuated in a material of greatest esthetic value, durability, and fidelity of reproduction. Doubtless improvement of cold-curing resins will soon further simplify laboratory procedure as well as decrease the now uncontrollable dimensional change.

Even though it is usually unnecessary to display much base material, skillful carving and tinting[13] enhance the patient's appreciation and acceptance of the finished dentures, and is a worth-while refinement. Its present vogue is believed, however, to be out of all proportion to its real esthetic value. Hygienic care and cleansibility are also of importance. These factors preclude exaggerated lingual carving, deep stippling, and roughness of the finished dentures. Some of the bizarre effects occasionally observed detract greatly from the esthetics, cleansibility, and tactile comfort to the patient. A simpler and more restrained effort is believed to be in better taste. "De gustibus non est disputandum."

After processing, the dentures are returned, on the indexed casts, to the articulator for correction of occlusal disturbance due to dimensional change. Further occlusal refinement is accomplished by mouth spot-grinding, using a central bearing stabilizing point.

SUBSEQUENT CARE

The responsibility of the prosthetist does not cease upon delivery of the dentures. It is believed that dentures made according to this simpler concept require less alteration and adjustment than those constructed by some of the more elaborate and complex techniques. Nevertheless, patients should be recalled twice yearly for a check of occlusion, vertical change, and tissue health. Thorough cleaning and removal of calcific deposits should be done at this time. Any marked closure of vertical dimension should be corrected. This may sometimes be accomplished by relining the mandibular denture. When this is unfeasible, new dentures are advised for the patient's benefit. The fact that simpler and, perhaps, less costly procedures have been employed will encourage the dentist, as well as the patient, to assent to new denture replacement when it is indicated. An understanding should have been established at the very beginning that denture service is a professional endeavor extending throughout the life of the patient. Dentures should not be considered a commodity to be purchased

at excessive cost and worn after their period of maximum efficiency and pleasing appearance has elapsed. This is definitely not an endorsement of low-fee denture service, but it is believed that a middle ground is most equitable. While not the primary consideration, simplification of procedure should provide a more economical service to the populace, avert encroachment by subprofessional groups, and help to forestall socialistic trends—all this with less stress and strain on both patient and dentist, and with a better end result.

This philosophy of denture prosthesis is not impulsively advocated[14] without due trial and consideration of other methods. It is recommended after an experience of thirty years of teaching and practice. I am greatly indebted to Campbell[15] for guidance during my formative years. No thought of disparaging the efforts of those who cling to a more complex concept exists or is intended. All sincere workers have contributed much to the fund of available knowledge. I believe, however, that many of the more complex and intricate procedures provide only an interesting hobby for the dentist, which benefits him more than his patient.

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FULL DENTURE SERVICE AS INFLUENCED BY OUR UNDERSTANDING OF TOOTH SELECTION AND ARTICULATION

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I WISH to discuss occlusal coordinations as an essential to denture stability and service, but first it seems most important to evaluate full denture prosthesis as a health service. Oral discomfort precludes full health for full living which should be every normal person's rightful heritage. It results in the loss of normal rest, promotes irritability, loss of vigor, efficiency, and employability. Many people are seriously ill physically and mentally due to inadequate or inferior denture service and the associated oral discomfort and can never be restored to health and normal living until they receive an efficient denture prosthesis. The most serious effect of continued oral discomfort is not the oral condition apparent in the mouth. It is the effect of continued oral discomfort upon the general nervous system and indirectly upon organic function. The rendering of a denture service, to meet the biomechanical needs of the patient, is a health service equal in importance to that of any other specialty in dentistry or medicine. It represents varied problems not only relative to oral anatomy but, fully as important, the state of the health of the patient. Many dietary deficiencies are common, and must be treated with vitamins, liver extracts, and mineral compounds. Mouth care (cleanliness), progressive shrinkage and changes of supporting tissues necessitate periodic alteration or renewal of denture bases to maintain functional efficiency.

Denture prosthetics is a service which not all dentists are equally qualified to render, yet some dentists are reluctant to recognize their inability to care for the more difficult denture problems. One's inability to master every phase of his profession in either diagnosis or treatment is not prejudicial to his professional standing or welfare, if he recognizes these facts and directs his patient through channels where they may receive efficient treatment. Progressively, we are recognizing and referring patients to fellow practitioners who have special training in certain phases of dentistry. Too often, however, denture failure is attributed to poor supporting ridges or lack of patient cooperation or adaptability. Too seldom is a failure recognized as due to one's limited ability to cope with the unusual problem.

The possibility of this service being rendered by the dental laboratory technician who is untrained in the biologic sciences has been mentioned. No one seriously interested in public welfare who is familiar with the biomechanical aspects of denture service and their relation to health could make such a suggestion.

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I cannot resist the urge to discuss denture prosthesis as practiced in England today. Recent discussions relative to eliminating prosthesis as a free health service leads us to believe that it isn't properly evaluated as a health service. Fee schedules granted have classed all cases into one group as to time essential to treatment. Fees have forced lowering or disregard of standards. Only free enterprise can stimulate the unusual interest, effort, and time expenditure essential in rendering an adequate prosthetic health service. In the interest of public health, we must strive to give the dentist who is responsible for the rendering of this important health service progressively better training in all basic sciences related to denture prosthetics.

The articulation of teeth has been spoken of as the most important science in the practice of dentistry. This is unquestionably true in the practice of full denture prosthesis. The initial factor is the occlusion of the teeth in harmony with centric maxillomandibular relation, a static relation of the teeth with an even innocuous distribution of stress over the entire denture bearing area.

There are many ways of securing an accurate centric maxillomandibular relation record. All of them require judgment and meticulous dexterity of the dentist. I use intra-oral wax check records; then checking and proving the accuracy of the maxillomandibular relationship after teeth have been positioned for esthetics and the desired maxillomandibular opening has been established. This procedure was outlined by me[1] 1932, and more recently by Trapozzano.[2] The technique is based upon the fact that the only record that can be exactly reproduced or duplicated is an accurate one, one in which condyles are in their normal rest position in the glenoid fossae and an even distribution of stress is exerted over the denture-bearing area without a movement or displacement of the denture bases. It is quite impossible to reproduce exactly a protruded or eccentric record, a record with uneven occlusal stresses or the same displacement of bases upon the tissue.

The obtaining of an accurate centric relation record, however, is not enough. Dentures cannot be processed without disturbing this relationship. Too often dentures are removed from the articulating instrument for processing and never returned to the instrument for the correction of occlusion in both centric and eccentric relations after the completion of the dentures. Such dentures cannot occlude properly in either the centric or functional eccentric positions. Such dentures cannot be used with the comfort or functional efficiency to which a patient is entitled. They produce rapid pathologic changes of the supporting ridges. The neglect of a dentist who knowingly fails to correct or harmonize occlusion of dentures following processing is inexcusable.

With few exceptions, the prosthodontist of today recognizes the necessity of coordinating tooth inclines and of minimizing horizontal stresses as an important factor in denture stability and the maintenance of oral health.

In consideration of this problem, we must visualize the factors controlling horizontal stresses and posterior tooth inclines. The most important factor and the one quite within the control of the dentist is the incisal guidance. The incisal guidance and Bennett movement, for all practical purposes, control the lateral inclines of posterior teeth on the working side. Incisal guidance and the anterior

incline of the glenoid fossae control the steepness of balancing cusp inclines. Due to the closer proximity of the incisal guidance, its influence is greater than that of the condyles. For functional harmony in all lateral positions, all posterior tooth inclines regardless of make or form, anatomic or nonanatomic, must conform to these three guiding factors: incisal guidance, lateral or Bennett movement, and forward incline of the glenoid fossae. All intermediate movements are controlled in a similar manner.

A steep incisal guidance seems to be contraindicated in a full denture prosthesis. The incisal guidance is the only means of controlling and reducing horizontal stresses. In considering the nonanatomic tooth versus the anatomic tooth, the nonanatomic tooth may be more readily adapted to a desired incisal guidance but, if we have functional balance in all eccentric positions, the lateral inclines and horizontal stresses are the same regardless of tooth form, anatomic or nonanatomic, when both are used with the same favorable incisal guidance. The nonanatomic tooth is most often used with a near horizontal incisal guidance while the anatomic tooth is used with a steep incisal guidance.

McLean[3] has aptly said, "Traumatic occlusion—antagonism between opposing teeth—lies not in the cusps per se, but in the misplacement or incorrect angulation of cusps. The solution lies not in removing the cusps but in properly placing and coordinating them."

In a discussion of the anatomic versus the nonanatomic tooth, we must always remember that the incisal guidance is the prime factor in controlling posterior tooth inclines. The steepness of the incisal guidance is under the dentist's control. The reduction of lateral inclines is an important factor in reducing tissue trauma and maintaining denture stability. The cuspless tooth is normally used with a horizontal or "minus" incisal guidance. The so-called "10 degree" or "20 degree" posterior tooth is used with an incisal guidance the incline of which might be from 10 to 20 degrees. The normal so-called anatomic tooth is carved to articulate best with an incisal guidance of 30 degrees. There is no reason, however, why the anatomic tooth cannot be reshaped to reduce cusp inclines to articulate with a horizontal or nearly horizontal incisal guidance. Anatomic teeth so shaped and arranged cause no more horizontal stress to denture bases or tissue trauma than nonanatomic teeth. They seem to possess greater functional efficiency.

Experience with various tooth forms has led me to believe that the most favorable denture balance and stability can be obtained with the anatomic tooth form. I use the so-called 30 degree cusp tooth and reduce and coordinate the inclines by selective spot grinding as discussed in my articles previously published.[4,5] All cases are coordinated with a horizontal or nearly horizontal incisal guidance.

Tooth inclinations have been liberally discussed in dental literature with perhaps too little understanding of factors which influence tooth inclines, and to what extent these factors may be controlled by the dentists. Discussions of the virtues of the nonanatomic tooth versus the anatomic tooth are most often influenced by so-called horizontal stresses which may be associated with each form, without again giving consideration to means of modifying the anatomic tooth, so

that horizontal stresses associated with its use are no greater than those associated with the nonanatomic tooth and retaining the desirable features of the anatomic tooth.

Fig. 1 shows the framework of a commonly used articulating instrument. The factors involved are the same regardless of the instrument used, whether it might be a more simple or a more complex mechanism.

The molar tooth relation and the instrument indicate a movement to a left lateral position, the left side here being the working or functioning side. The three factors controlling this movement are the forward movement of the condyle head on the incline of the glenoid fossa on the right side; on the left side there is a rotation and a lateral shift or the Bennett movement, and in the anterior, the incisal guidance. The incisal guidance of the instrument is a mechanical device for convenience set to reproduce the guiding inclines of the anterior teeth. The anterior controlling factor in a left lateral movement is normally the lingual incline of the left upper anterior teeth—most often the cuspid tooth.

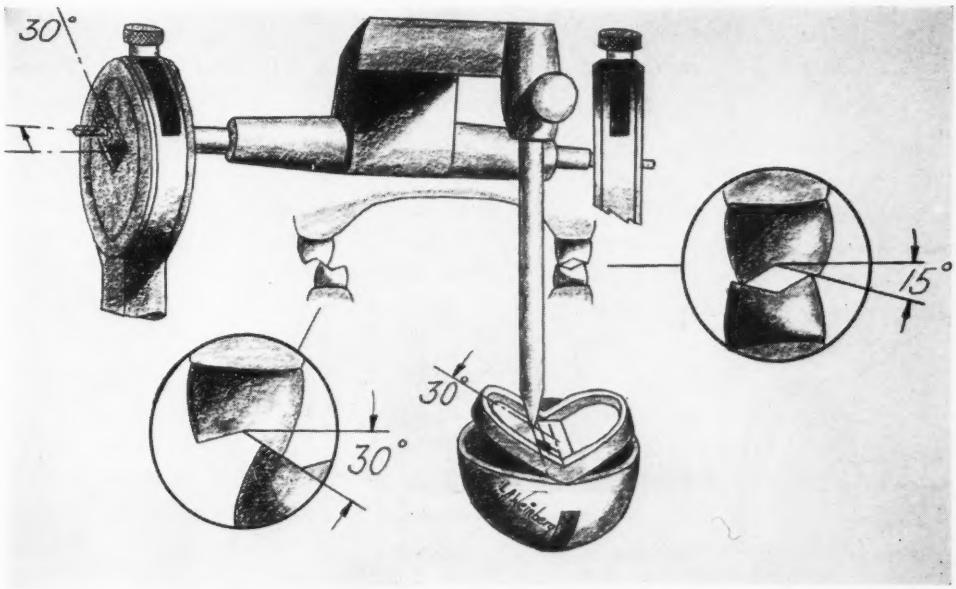

Fig. 1.

The condylar guiding factors are given to us by the patient and are not within our control. When making artificial dentures the anterior factor or incisal guidance is to a great degree within our control. Esthetics may at times be an influencing factor.

On the working (left) side in functional movement, the lower buccal cusp points function upon the lingual incline of the buccal cusps of the upper tooth, while the upper lingual cusp functions upon the buccal incline of the lingual cusps of the lower tooth.

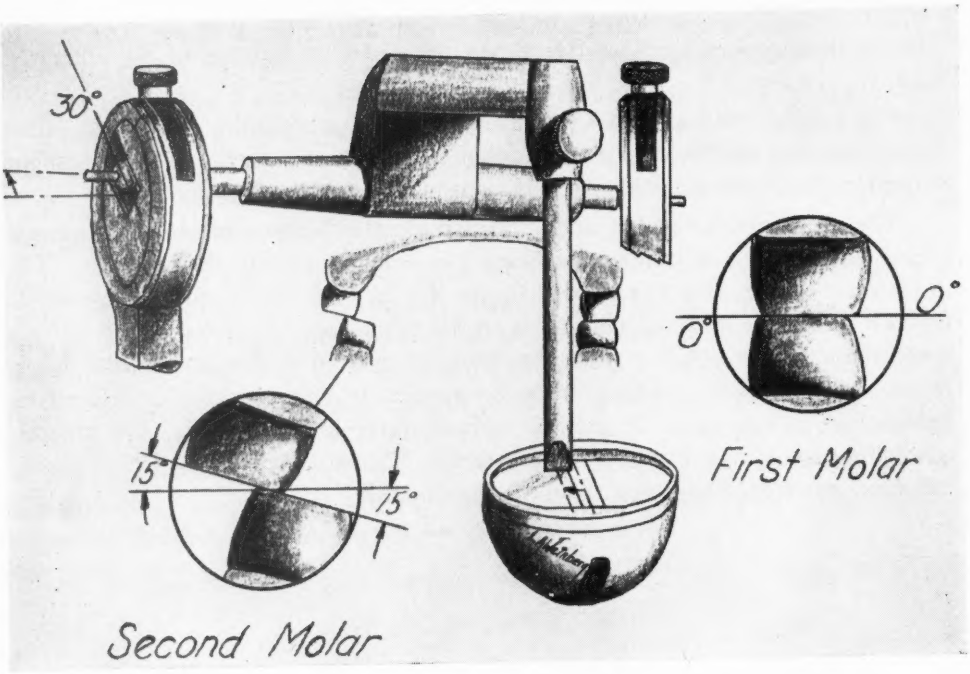

Fig. 2.

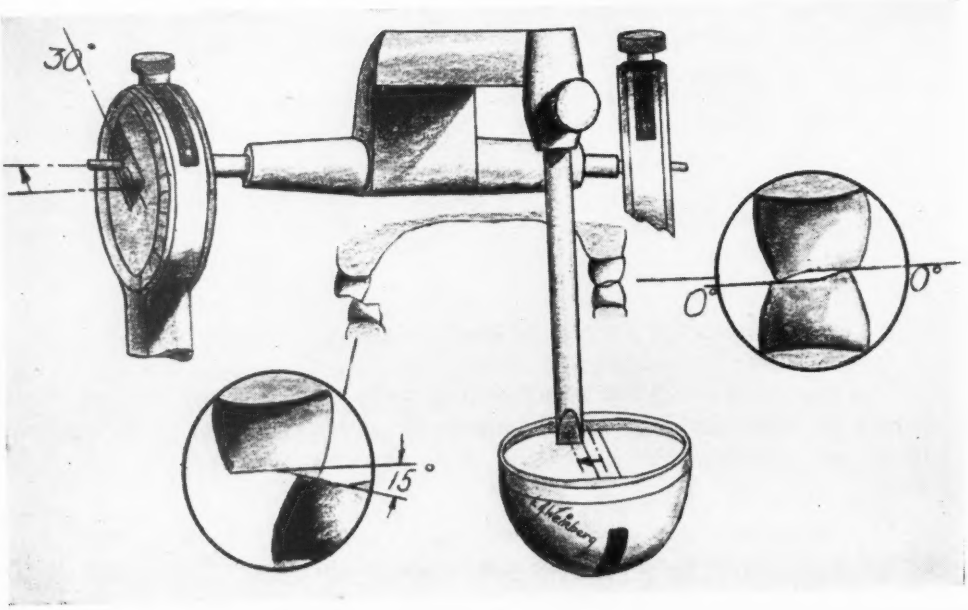

Fig. 3.

The teeth on the left or working side are almost on a direct line between the condyle on the left and the incisal guidance. The anteroposterior steepness of the functioning incline of the right condyle has a negligible effect upon the lingual incline of the buccal cusp of the upper tooth and buccal incline of the lingual cusp of the lower posterior tooth on the left or working side. The rotation and Bennett movement in the left condyle, and the incisal guidance are the two factors which control these inclines (buccal of the upper tooth and lingual of the lower). In the mouth, the anterior or cuspid guidance has the greater influence upon inclines of these teeth due to its proximity to the posterior teeth.

The inclination of the Bennett movement in this instrument is 0 degrees. The lateral incisal guidance of the instrument is set at 30 degrees. The lingual incline of the buccal cusp of the upper tooth and buccal incline of the lingual cusp of the lower tooth midway between these two guiding factors would be 15 degrees. These inclines of cusps of teeth nearer the incisal guidance must be steeper. Those nearer the condyle must be progressively less steep. The condylar incline on the right side is set at 30 degrees. This, with the incisal guidance, controls the steepness of all balancing teeth inclines, that is, the buccal inclines of the lingual cusps of the upper teeth and the lingual inclines of the buccal cusps of the lower teeth. With a 30 degree incisal guidance and a 30 degree inclination in the glenoid fossae, all balancing inclines would be 30 degrees.

Fig. 2 shows a nonanatomic or cuspless tooth. These teeth are most often set with a flat incisal guidance. With a horizontal incisal guidance and a horizontal Bennett movement, all teeth in function on the left or working side would have to be set at 0 degree inclination. The balancing contact here is controlled by the 30 degree incline in the condyle and a horizontal incisal guidance. A balancing contact of the second molar which is approximately midway between these two guiding factors must have an incline of 15 degrees.

In Fig. 3, let us maintain the same horizontal incisal guidance with the same posterior guidance and note the effect upon the inclines of an anatomic tooth. All guiding inclines on the left or working side will be 0 degrees, the same as with the cuspless tooth. The balancing inclines are also identical with the balancing inclines of the cuspless teeth.

Thus the reduction of the incisal guidance is the only means of controlling the steepness of posterior tooth inclines. And by using the same steepness of the anterior guiding factor (incisal guidance), horizontal stresses will be the same if we have a balanced occlusal relation regardless of whether we use an anatomic, a cuspless, or a Pleasure type tooth.

CONCLUSIONS

Denture prosthesis is a science and an art. It is a health service equivalent to any other specialty of dentistry or medicine. Its success is based upon the dentist's knowledge of biologic and mechanical factors. He must possess judgment in recognizing problems which will complicate denture service, such as: poor general health as influenced by age; dietary deficiencies; diabetes and other sys-

temic factors; mental attitude, and ability of readjustment; anatomic conditions such as poor ridges; undesirable prominences and unfavorable jaw relation.

He must possess resourcefulness in understanding and capability in varying techniques in order to meet unusual oral conditions; he must have resourcefulness to meet the unusual mental reactions of the patient, unusual craftsmanship and artisanship, and, above all, a willingness to assume responsibility.

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IMPRESSIONS FOR FULL DENTURES

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THE procedure I present is neither new nor revolutionary, but the facts I have gathered attendant to this procedure are interesting and present a factor for some thought and consideration.

It has always seemed to me that if we could obtain a perfect moulage of the denture-bearing areas and construct dentures upon casts made from such impressions, it would be the ideal. This would represent a duplication of the form of tissues at rest. A denture constructed from such an origin would represent an exact negative of those surfaces upon the tissue side of the denture. This would be, in fact, an impression of tissues without distortion or displacement, and the completed denture would not have these detrimental attributes incorporated into it.

PREMISE

The premise upon which this work is based is that a good impression is initially the most important factor in the construction of good dentures.

This particular subject in full denture procedure has always been a source of debatable interest and many authors have given it its respected position of importance. On the other hand, many have relegated it to a lesser degree of importance in comparison with such subjects as occlusion, phonetics, esthetics, tooth form, et cetera, but I am sure that was only because of their interest in their specific topic at the time.

Of course, I am not for one moment depreciating the importance of diagnosis and occlusion and all of the attendant evaluations necessary to establish a practical occlusion, nor any other single factor that may comprise the cooperative chain necessary to produce dentures that are biomechanically correct. Nevertheless, without a good impression, our objective may not be attained. Far more important, I think, is the making of an impression that will not contribute toward the destruction of the ridges, all the other afore-mentioned factors notwithstanding, and not the making of the impression with the intent to give a patient the so-called "tight fit."

The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or reflecting the views of the Navy Department or the naval service at large.

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MATERIALS VERSUS PROCEDURE

For many, many years the peer of all impression materials was, and still is, plaster of Paris. It must be noted that this type of impression material also represents a principle. The character of the material precludes the possibility of introducing the element of excessive force when the impression is being made. This principle of the elimination of force from impressions also represents an era in our denture procedures.

It is interesting to note that we had stepped from an era of a relative no-pressure procedure in making impressions into an era of impression making with force. Some procedures even designated the pressure in pounds to meet the requirements.

In reviewing our impression procedures over the past twenty-five years, one may note the change after full plaster impressions began to be discarded. The various forms of modeling compound and waxes appeared. There was modeling compound used alone; modeling compound trays with plaster washes; washes with modified plasters such as Truplastic, Gelum, Plastogum, Solvite, et cetera; then the various waxes painted or flowed upon molded trays; the pastes—hundreds of them—of varying compositions but basically zinc oxide and eugenol; and then the acrylics and varying delineations of the plastics. All of these and many more, used as they were, confined in an adapted tray which did not allow full escape of the introduced force when the impression was made, represented the positive pressure era of impression making.

A few years ago we began to hear such terms as "mucostatics," "negative pressure," et cetera. "Reduce the force" was the cry. It was a complete reversal from the procedure which had been heretofore advocated. Many dentists were changing their entire impression procedure, yet the old timers who were still making plaster impressions and had seen these changes occur through the years just sat back and smiled. They never did have any trouble.

What was the trouble and why this trend? There can be only one answer. Dentists who had been practicing long enough were beginning to see evidence of tissue destruction in mouths of their edentulous patients and they began to wonder why. They began to suspect that something in their procedures may have been the contributing factor to this breakdown. I believe it was the impression.

Any force that may be incorporated into the impression must be incorporated into the finished denture. I repeat this statement because of my firm belief of its importance.

As tissue in the mouth is easily moved, any pressure can very well displace or distort it. We all know that normal physiologic processes will not tolerate confinement nor distortion of any tissue in the body without some retrograde process ensuing. This is just as true of tissue under a denture. In fact, greater damage can be done to tissue under a denture because of the many indirect factors involved that could contribute to the breakdown process, such as lowered resistance

of the patient, faulty occlusion, et cetera. The usual sequence of events follows: continued complaints by the patient of sore spots in the mouth with subsequent local relief by grinding relief into the denture. Repeat this process often enough and the usual tissue breakdown progresses until the denture becomes inadequate. What has happened to the "tight fit" that you were so proud of when you delivered the denture? That question is often very embarrassing and our answers to the patient are too often meaningless.

Because I was positive that the character of the force involved in making an impression of an edentulous mouth was an important factor in the establishment and maintenance of a more permanent denture-bearing area, I decided to conduct an experiment so I could evaluate and establish the practical factor as proof of my theory.

The type of material used is not important. I must insist that you bear this point in mind at all times. The prime principle involved is to be able to make an impression with the least amount of applied force. In order to accomplish this, the vehicle used must fulfill the following requirements: (1) A tray that is oversize but properly fitted. (2) Sufficient avenues of escape for the impression material must be provided in the tray. (3) The material must flow freely and have a setting time sufficiently slow to allow for the dissipation of introduced force. (4) The material must reproduce the surface tissue in the impression with fidelity.

If you will evaluate these cardinal principles, you will note that many types of materials will meet the requirements. As I stated, plaster was the impression of choice, but I encountered too many difficulties with it in the service, particularly at the beginning of World War II, to continue its use. Not all of our technicians were well trained at the time, and problems of breakage and separation of impressions from casts began to present too great a factor for safety and security for a successful end result.

ALGINATES

The alginates appeared on the scene some ten years ago. I began experimenting and exploiting the possibility of their use for full denture impressions as a substitute for plaster. In the early days of their use there were many disadvantages, but most of the alginates today equal the performance of plaster. The only disadvantage may be the fact that the creation of the cast must be accomplished at once. There must be no intervening time between the completion of the finished impression, its preparation, and the running up of the cast. Overlooking this very important requirement may result in a faulty cast and subsequent failure.

The results obtained from impressions made in the prescribed manner with this type of material proved very gratifying, both to the dentist and the technician. The time required to make the impression was reduced. The invaluable asset to the dentist was to be able to feel confident that the impression, when completed, left no doubt that it was a good impression, and that a successful denture could be built on a cast made from it. The following facts were established over a sufficient period of years to make recognition noteworthy.

THE PROJECT

In the observation of some 5,000 denture wearers in the service, for whom I was personally involved in the construction of their dentures, I became particularly interested in the theoretical aspect of what the impression procedure may be contributing toward the ultimate maintenance of the ridges. Over 400 patients were selected who had been edentulous for not less than one year. This requirement was established to allow for a maximum time for resorption following extraction. Many mouths had been edentulous for several years. The average age of the patent was 26 years. The age of the patients ranged from 17 to 72. Medical histories were checked so no patient was included who had any systemic involvement so there might not be any reflection from pathologic foci that would have a tendency to break down tissue.

The selected patients were divided into two groups. The impressions were made with alginates for one group, and with modeling compound muscle-trimmed trays and either plaster or impression paste washes for the other. I will refer to the alginate impression as the no-pressure type and to the other impressions as the pressure type in this report.

The project was explained to each patient. They were told that dentures were to be constructed, and that periodic checks would be made of these dentures for at least two years. All that was required of them was to report at the appointed times, and relate their experience, and then have their mouths and dentures examined. No mention was made of the difference in the impression procedures.

The degree of security of the denture was noted when the occlusion was perfected and the dentures were delivered. This observation was made by the feel of the dentures in place and by various tipping forces required to dislodge them. All factors were recorded. All patients' remarks relative to their feeling of security were also noted. The patients were seen at regular intervals of thirty days.

The same questions were asked at each appointed date: (1) Have you any trouble? (2) Are there any sore spots? (3) Are you able to chew all food without disturbance? (4) Does your denture feel as tight as it did when delivered?

Any noticeable change of tissue tone as well as the patient's experiences were noted. If a patient was seen between appointed dates for any correction, this was recorded. All observations were a combination of clinical evidence and patients' reports.

Standards for the observations in the experiment were as follows:

1. All supporting bases were considered to be undergoing a definite change if patient reported with sore spots after the first six months.

2. The observation of the patients and recorded evidence of their experiences were established on a basis of clinical comparison to rule out oral accident (aphthous ulcers, mucous membrane injury other than by the denture, et cetera) or unnecessary complaints.

3. Repeated complaints were met with an immediate reconstruction of the denture on the assumption that some other factor may have been the disturbing element.

4. Study casts were made every three months for comparison with original cast by measurements.

5. Periodic intra-oral roentgenograms were made for comparative studies of bone formation.

PERTINENT FINDINGS

These observations were completed on 354 (82 per cent) of the original 426 patients. Because of transfer or other exigencies, the remaining 18 per cent were not observed the full two years as originally planned. Fortunately, of the patients remaining, 185 had no-pressure impressions and 169 had pressure impressions. These were divided evenly enough so that our intent to observe the differences in mouths as the result of the two types of impressions was not disturbed.

TABLE I

REPEATED SORE SPOTS 6 MONTHS TO 1 YEAR	
NO-PRESSURE (%)	PRESSURE (%)
3	47
Duplication or Remake Necessary at end of: 12 Months	
5	93
18 Months	
9	100
24 Months	
15	0

Of particular interest was the character of the disturbance or change. There was distinct clinical evidence of tissue change as indicated by a comparison of the study casts. Casts made at the initial sitting were compared with those made at later dates. Certain dimensional changes were noted which gave rise to the belief that some retrograde process had occurred. The significant difference in the appearance of the tissue in the mouths with dentures made from pressure impressions and those made from no-pressure impressions was quite evident. Inflamed areas were noted, and varying degrees of hypertrophied tissue was in evidence where pressure impressions had been made. In mouths with dentures made from no-pressure impressions, the tissue showed no degree of breakdown even when duplication was necessary after two years.

THE PERIPHERY

One of the controversial subjects in full denture procedure is the importance of the periphery. This work has proved conclusively that it is not important as a retentive factor, and often is more detrimental than good. The border of the denture should only conform to the outline of the denture-bearing area. It is only when this area is lost or destroyed that the peripheral border on the denture is increased to secure retention temporarily by utilizing the adjacent soft tissue.

The use of the misnomer "muscle-trim" in our prosthetic literature and teaching should be either revised or stricken from the books. It is impossible to trim a slowly cooling modeling compound or wax border, or setting wash, by molding border tissues without distortion or displacement of these tissues. Peripheral tissues must be able to cut through the impression material, and mold themselves into it without movement or external massage. Those who may disagree with this statement need only to review the anatomy, and note that the origin and insertion of muscles of mastication and muscles of expression do not emerge on or near the ridges.

Tissue attachment at the frenula and at the bicuspid and molar areas is the only factor to be considered beside the normal extension of the periphery to the flexure line if desired. I say if desired because, if the denture-bearing area is sufficient, the extension of the periphery is of no importance. The freedom of the tissue attachments is necessary for comfort and adequate space. To allow these attachments freedom of movement means simply that they are not included in the border outline.

This work has revealed the relative importance of atmospheric pressure or surface tension as physical forces involved in the retention of dentures. The following statement is made in view of the findings. Retention is purely the result of the fidelity of the adaptation of a surface that has engraved upon it a replica of the surface it is to contact. The intervening meniscus, the saliva, creates the medium of contact of the interfacial surfaces. As the outer forces, such as the forces exerted in occlusal contact after masticating food or swallowing, are increased the degree of retention of the denture is also increased since the thickness of the meniscus is decreased and the surfaces come into closer contact. As the outer force is released, the denture is also released from its contact tension, and subsequently the tissues are again at rest. We know from fundamental physiology that normal cellular activity is conducive to tissue health. The positive stimulation that is afforded the tissues underneath these dentures during mastication must certainly contribute to the health of these tissues as evidenced by these findings.

Some of these dentures were made for aviators and those constructed from pressure impressions, which of necessity had a peripheral seal as part of their retentive factor, could not be retained at high altitudes. The air that was trapped underneath the dentures expanded with the decrease of the external air pressure and forced the release of the dentures. There was not fidelity of reproduction of the surfaces on the denture so surface contact could not be established.

The patients with dentures made from no-pressure impressions encountered no difficulty at varying altitudes because the surfaces in contact were not dependent upon any false force for retention, such as is created by a peripheral seal. The dentures were not disturbed when the barometric pressure reduced this semivacuum which was created by a seal.

Various dentists, using any number of different procedures, will vary the design of their denture peripheries. Nevertheless, all are successful, temporarily

at least. I am almost sure that, given the same mouth, these various designs would appear just the same as for different mouths if a number of men were to make the impressions. If the contacting surfaces between the denture and the tissue are as near parallel to each other as possible, the greatest resistance to dislodgment of the denture would be achieved. The elemental experiment of two slabs of glass with a small amount of moisture between them is a good example of the retentive force. It is nearly impossible to pull the glass slabs apart by a force applied at right angles to them, but it is easy to slide one off the other. Flat mouths, which have always been characterized as the "toughies," will be the easiest because they are similar to the surface on a glass slab. Lateral movement is neccessary to slide the denture or dislodge it. For this reason, dentures made for mouths with large ridges do not necessarily have greater retention. The retention value in these mouths will be reduced because the parallel surfaces are smaller in area and the perpendicular area is proportionately larger. However, lateral movement is limited by the perpendicular areas. This helps to retain the denture. For these reasons, we may dispense with the periphery as a retentive factor. The spectacular and theatrical performance of a clinician showing a patient with dentures exhibiting an outstanding quantity of retention means absolutely nothing, because the extended peripheries enveloped by soft tissues will exclude air and create the maximum amount of so-called suction temporarily. One of the manufacturers of impression materials even suggests occluding the sublingual space to such an extent as to make an immovable base. All this would be good if the permanence of the tone of the soft tissues could be guaranteed, and if the tolerance of the patient would not be exceeded.

ALGINATE IMPRESSION TECHNIQUE

1. Good modeling compound impressions covering all of denture-bearing areas and peripheral borders are made.

2. Plaster casts are formed in the impressions. Single thickness shellac baseplates are adapted on the casts to serve as spacers. This is done on very wet casts to prevent the baseplate material from sticking to them. Double thickness baseplates (or two single baseplates luted together) are adapted over these single thickness baseplates. The casts and single thickness baseplates are kept very wet while this is done.

3. With a No. 10 round bur, holes are drilled through the double thickness tray. The caliber of the hole is important. A bur of this size makes the right size hole, both for retention of the impression material and for dissipation of the force used in the making of the impression. A small handle is made off center on the lower tray with a piece of scrap baseplate material. A piece of dental floss is engaged in the tray holes of the upper tray to act as a handle.

4. The single thickness baseplates or spacers are tried in the mouth, and the peripheries are trimmed free of all tissue attachments. With all tissues at rest, the spacer should not be lifted by the tissue when this step is completed.

5. The spacer is placed into the double thickness baseplate tray. The periphery of the baseplate tray is trimmed to the border of the trimmed spacer. A small roll of utility wax is placed on the posterior border of the post dam area of the upper tray. This acts as a guide for the direction of the impression material toward the posterior border of the palate. A roll of utility wax is also placed on the lingual side of the border of the lower lingual flange of the tray and over onto the retromolar pad area. These wax rolls will act as bumpers to the tongue after the impression is placed in the mouth, and prevent the thinning out of the impression material when tongue returns to its rest position.

6. A small piece of stick compound is melted into the palatal portion of the upper tray and allowed to cool sufficiently to be placed in the mouth. The tray is brought to place with the minimum of pressure, but with sufficient pressure to obtain a small impression of the center of the palate. This compound is chilled and trimmed. It will act as a definite stop so that when the final impression is made, the tray may be centered without difficulty. It will provide for an adequate space, comparable to the thickness of the spacer, to accommodate the impression material. Similar stops are made on the lower tray in the bicuspid area on both sides. Care should be exercised on the lower to make sure that the stops engage ridge areas that are not movable.

7. The lower impression is made first. This generally acquaints the patient with the impression material, and the making of the upper impression is made much easier. The mouth is dried with dental napkins while the impression material is being mixed. An alginate impression material is used, but 5 c.c. more water is used than is indicated in the manufacturer's instructions. The specified temperature and spatulation time must be adhered to according to the manufacturer's directions. The upper tray is not overfilled. The lower tray is filled full. With the patient totally relaxed, the tray is introduced into the mouth, and the lips and cheeks are distended in order to watch the flow of the material around the borders of the trays. Digital pressure is immediately released from the tray. The setting time of these materials is from three to four minutes. This insures that there is no displacement of tissue nor force introduced in making the impressions. To prevent trapping air along the tuberosity areas, a small amount of the impression material can be placed there with a spatula before the tray is placed in position.

8. Impressions must be poured up immediately. Dry plaster is sifted into the impression and washed out with water. This removes all mucous and excess saliva. Some alginates require immersion in a fixing solution before the casts are poured. Casts are made of stone.

SUMMARY

The salvation of ridges is of paramount importance. Without a sound foundation our superstructure fails. I am more convinced than ever that the principle involved in this type of impression procedure is a distinct contributing factor to the maintenance and preservation of ridges. I have no intent to make

fabulous claims, and certainly I would not insult your intelligence by stating that this procedure will insure any degree of permanence of the denture-supporting tissues. As long as our patients continue to grow older, and succumb to the ravages of the enigma of tissue destruction with age, so long then will we continue to change dentures for our patients. The least we can do is attempt to deter this morbid process, rather than contribute to it.

Dental Detachment
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WHEN IS A SKELETON NUTRITIONALLY RETRIEVABLE?

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THE EXTENT to which the various parts of a skeleton, particularly the mandible and maxilla, are nutritionally retrievable is dependent upon numerous factors many of which are beyond the scope of this paper, for example, the role of the endocrine system. Three factors quite dependent upon each other and intimately connected with the title of this paper are: time (age), food and nutrition. Time is defined as "A period set apart in some way; hence, variously, a spell, a moment, a generation, an age, an era, an epoch, etc."[1]

This discussion has been organized from the standpoint of *time* as it relates to the terms *age* and *era* as follows: (1) Age as it refers to the age of our audience and also to your patients since prosthodontists serve largely the middle and older age groups in the population. (2) Two eras: (a) before 1925, that is, before modern pediatrics, and (b) from about 1925 to the present time, that is, since modern pediatrics. The age range of this audience is probably between 40 and 55 years, plus or minus ten years, hence we represent the first era, before modern pediatrics. Two fair questions are "How many persons in this room developed teeth as good as their dental inherited potentials permitted," and "How many have a skeleton, especially the mandible and maxilla, as good as they might have had if all that is now known about nutrition and its relation to tooth and bone formation and maintenance had been known and practiced not only during infancy, childhood, and adolescence, but also during the past thirty to forty years?" We know that it is simpler to build a new house than to rebuild an old one. The same is true of the mandible and the maxilla.

Food may be defined as anything which when taken into the body serves to nourish and build tissues or to supply heat. In addition to this definition, food must be considered from the standpoint of economics, which includes production, distribution, and cost. Types of foods, such as meats, milk, eggs, fats, oils, fruits, vegetables, cereals, and legumes and products made from them present complicated problems of food storage, preservation, and transportation. All of these factors and many more, among which is climate, influence what foods will constitute the diets of peoples and individuals in the various parts of the world. Many of the processes concerned with food preparation, storage, transportation, and preservation have a direct bearing upon food's nutritional value when it reaches the dining table.

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Nutrition may be interpreted as the ingestion, assimilation, and utilization by the body of adequate amounts of all dietary substances needed for growth, maintenance, and repair. Intake of food and assimilation of it are not necessarily related. Nutrition also refers to the specific functions in the body of proteins, fats, carbohydrates, minerals, vitamins, and water, and to the individual dietary requirements for these factors.[2]

For purposes of discussion of the relation of time (age), food, and nutrition to the nutritional retrievability of the skeleton, especially the mandible and the maxilla, and also the health of the oral mucosa of persons in this audience or in patients of similar ages, the life span may be divided into the following age periods:

1. Prenatal period
2. Infancy: birth to 2 years*
3. Early childhood: 2 to 6 years
4. Later childhood: 6 to 10-12 years
5. Adolesence: 10-12 to about 20 years
6. Maturity: From about 20 years to about 45 years
7. Later years: Over 45 years of age

SOCIOBIOLOGIC FACTORS

Not only food and nutrition but also sociobiologic factors may exert satisfactory or unsatisfactory influences at any or all of these periods. Sociology is the science of social relationships and their phenomena; biology is the science of life and living organisms, including man. Sociology includes the social background of an individual and, as influenced by health and nutrition, determines in part at least whether the inherited biologic potentials may be or may not have been fulfilled. One needs only to mention the depression years from about 1930 to 1938 in order to recall how the dental-medical-nutritional programs of thousands of persons were interrupted and to realize the tremendous role which the sociobiologic factors may play in the life of an individual, in a family, and/or in the life of a community.

During the depression years some of you were getting your practices started, and patients were few; some of you were well established but regular patients postponed needed dental repairs due to financial reverses. So, whereas dental services were available in 1932 for Mr. and Mrs. John Doe, ages 40 and 37 years, respectively, and their four children, Bob, age 13; Jack, age 10; Judy, age 7; and Susan age 4, they could not afford it. Our hypothetical family lived in Berkeley, Oakland, San Francisco, or any other American city and represented the middle-income group. They were buying their home on one of the avenues in the suburbs and had a family car. There was no space for a backyard garden so all foods had to be purchased.

During the depression Mr. Doe had only a part-time job, even though he had a college education, so it was necessary to use all of their savings for living ex-

*These age periods are only relative.

penses. Conditions began to improve after about 1938 but not much money was allotted for dental care due to the many other demands of a growing family. From about 1940 to 1945 it was difficult to secure dental appointments, especially for young and teen-age children, so again the Doe family had only part of the professional dental care they could now afford. In 1940 Susan, then 12 years old, began orthodontic treatments at a private office. Due to the nature of the problem, it could not be handled at the University of California Dental Clinic. Hence, the cost was greater than it would have been at the Dental Clinic, which meant that Mr. and Mrs. Doe delayed further their needed dental work.

It is now April, 1952. There are many conditioning factors which we do not have time to discuss which could have influenced the present dental status of the Doe family. However, an analysis of the eras through which the family have lived serves to illustrate what such a family's dental potentials may be if you have its counterparts as patients today. The three factors mentioned earlier, namely, time (age), food, and nutrition, and the presence or absence of professional care determine in great measure the extent to which the mandible and the maxilla may be nutritionally retrievable. Prosthetic problems due to poor occlusion which may result from certain facial patterns, or other causes known to dentists, and which may result in poor nutrition of the maxilla and mandible and play a role in atrophy of these bony structures, are outside the realm of this paper.

Table I gives data on the Doe family which may have a direct relationship to their present dental status.

TABLE I

MEMBER OF FAMILY	YEAR OF BIRTH	AGE IN 1925 (BEGINNING OF MODERN PEDIATRICS*) (YRS.)	AGE IN 1932 (DEPRESSION YEARS—1930-1938*) (YRS.)	AGE IN 1940 (WAR PROSPERITY—1940-1945*) (YRS.)	AGE IN 1952 (YRS.)	BODY BUILD (FRAME)	PRESENT	
							HT.	WT. (LB.)
Father	1892	33	40	48	60	Light	5′ 10″	185
Mother	1895	30	37	45	57	Medium	5′ 4″	145
Bob	1919	6	13	21	33	Medium	6′ 2″	175
Jack	1922	3	10	18	30	Large	6′ 0″	180
Judy	1925	Infant	7	15	27	Medium	5′ 7″	125
Susan	1928	—	4	12	24	Medium	5′ 6″	130

There are four grandchildren, born since 1945, three boys and one girl.

Father, Mother, Bob, and Jack were born before 1925, that is, before the era of modern pediatrics, so they may or may not have developed teeth as good as their dental inherited potentials permitted.† Since Bob was 6 years and Jack 3 years in 1925, they should have had some medical-nutritional advantages during

*These dates are only relative.

†Climate (amount of sunshine available) is a variable which may have been a source of vitamin D, long before the vitamin D in cod liver oil was discovered in 1922.[3]

early dental development which their parents may not have had. Judy and Susan should have had modern pediatrics, so unless illness or some metabolic disturbance upset the dental-medical-nutritional program, they should have developed teeth as good as their dental inherited potentials permitted.

Bob, Jack, and Judy were in their adolescent years during the depression era. Foods conducive to poor mouth hygiene were cheap during these years and were used in abundance by many families in cities and towns where all foods had to be purchased. The Doe children like many children had little dental care during these years due to the economic factor. Judy and Susan represent one of the age groups in the 1940's which may have had too much spending money due to "war prosperity" and bought the things which children often buy which may be factors in poor mouth hygiene. Bob and Jack spent four years in the armed forces. Due to the nature of their assignments, their dental-nutrition programs were further complicated. Bob is now 33 years old and Jack is 30 years old. They represent the young adult group which may be dental cripples today due to circumstances beyond the control of their families and of society, namely, depression and war.

Full-mouth roentgenograms of Bob and Jack show considerable bone resorption and some drifting of teeth since each lost three of his six-year molars in his late teens and restorations were not placed. Bob has quite an advanced periodontal condition, and Jack needs periodontic treatments and other dental care. Due to a number of reasons Judy has been a "finicky eater" ever since the beginning of her adolescence, so she has not developed as good a bone structure as she should have developed if she had had a better food pattern, or had been of smaller stature. Her lower six-year molars are gone, with considerable drifting of the remaining molars which contain large gold inlays.

Susan, age 24, has the best bone structure and the least decay of the four children; she has her full complement of teeth. While she was under orthodontic treatment, from about 12 to 15 years of age, the orthodontist insisted upon excellent mouth hygiene. Susan not only had a good diet but apparently the dietary factors were well utilized because she built a good bone structure and the teeth have remained where they were placed. Due to lack of professional care, among other things, Mr. and Mrs. Doe lost some of their teeth through decay and some from a periodontal condition. They have had partial dentures for years and now need full dentures, but have almost no ridges to support them.

Undoubtedly, there are at least two questions which this discussion has raised: (1) Up to what age is a skeleton, especially the mandible and maxilla, nutritionally retrievable? (2) How long does it take to rebuild bone in a patient? It is, of course, fully understood by me that adequate nutrition can no more stimulate the jaw to grow a new ridge when the original ridge has been removed surgically or has been completely resorbed than it could cause a finger to grow a new joint to replace one that has been amputated. Owing to the intense interest in nutrition which has resulted from the spectacular researches on this subject, at times perspective is lost as to what is possible and what is impossible to accomplish with a highly satisfactory diet.

No answers which would apply to all persons can be given to either of the foregoing questions, but without doubt it may be said that all persons are not capable of the same degree of bone regeneration.[4] The problems presented to prosthodontists are similar in some respects to the problems of the orthodontists, except that the latter work with an age group whose health conditions are more favorable for building new bone, but unquestionably orthodontists also have considerable variation among their patients in this respect.

OTHER FACTORS

Since the prosthodontists work primarily with the middle and older age groups, time (age), endocrine imbalance, previous nutrition and health, and the condition of the digestive tract are a few of the factors to be considered when bone regeneration is needed. Owing to the frequency of digestive disturbances, and diseases such as liver diseases, diabetes, nephritis, ulcers, and hypertension in the middle and older age groups, all should be aware that at times diet problems are outside the realm of normal nutrition and become problems in diet and disease, and so should be handled by physicians. No unpleasantness should arise between dentists and physicians over the dietary problems of patients because all well-informed physicians today recognize the importance of nutrition in medicine.[5]

GERIATRICS

As a result of the tremendous advances in medical sciences of the past half century, the proportion of aged persons in the general population has been considerably augmented. An increase of about 15.5 years in life expectancy occurred in the United States between 1900 and 1942. In 1942 the average length of life in this country was about 65 years, an increase of almost one-third since the start of the century. Stieglitz[6] comments: "The aged are here now; there will be many more of them in years to come. Never before in the history of mankind has a like problem arisen; plagues, wars and famines have many times seriously changed the balance of population structure, but never before in the direction of a preponderance of the elderly such as is occurring today.

"The need to learn about the aging is urgent. The apparent boon of great longevity may become a curse, a terrible danger. Long life without health is not only an individual personal tragedy, but a social evil seriously threatening the national economy. Increased longevity with health and useful vigor into senility may be made an incalculably valuable asset to the commonwealth, if the potentialities of the elderly are wisely developed, guided, and utilized. The future course of events, economic destruction, or great enrichment of human life will depend in large measure upon the science and art of medicine. Such is the vast responsibility of geriatric medicine." This physician is probably unaware of the tremendous problems of prosthodontists with this aging and aged population. We may add "Such is the vast responsibility of geriatric dentistry, which presents problems which are different but undoubtedly as important to the aging and aged as many of those presented by geriatric medicine."

Geriatric medicine is not a sharply defined speciality and it is not limited to the study and treatment of only the senile portion of the population. It is essentially a point of view focusing attention upon the physiologic, structural, chemical, and psychologic changes which unquestionably begin about maturity or even earlier and are part of the aging process. It is concerned with the aging as well as the aged because it is realized that far more can be accomplished for the larger group of senescents than for those fully senile. It has proved practical to assume that geriatric medicine becomes applicable at approximately 40 years of age, for it is at this time that the insidious, progressive disorders so significant in later years become manifest. The actual beginnings of such common and important disorders as arteriosclerosis, hypertensive disease, hypertrophic arthritis, and the like occur far earlier than their signs and symptoms are clinically detectable. In many respects the two decades from about 40 to 60 are the most significant, because in these years of later maturity or early senescence the future health of the individual is in great measure determined. Geriatric medicine, according to Stieglitz[7], to be fully effective, must be largely preventive medicine. We would suggest that geriatric dentistry to be effective must be largely preventive dentistry.

DEGENERATIVE DISEASES

An important point often overlooked is that the so-called degenerative diseases have one characteristic in common, namely, the impairment of the nutrition of the parenchymal cells. Impairment of cellular nutrition may result from any one or more of several factors, among which are: (1) inadequate nutritional supply (such as dietary deficiencies, digestive failure, oxygen deprivation due to anemia); (2) inefficent distribution (circulatory impairments); (3) ineffective utilization of the food elements (hypoinsulinism, enzyme deficiencies, asphyxia); (4) accumulation of injurious debris (uric acid deposition, asotemia). Time is an extremely significant element in the development of gradual or insidious deficiencies in nutrition. Chronic lesions are slow in development, progress slowly, and even with adequate therapy often are slow in recovery. Some changes are irreversible.[8] It has long been known that chronologic age and biologic age are not synonymous and are frequently widely divergent. Aging changes vary widely between different persons and furthermore aging is not symmetric within an individual. Disharmonic senescence is a term used for the phenomenon of one organ or organ system aging more rapidly than other organ systems in the body.[9]

NUTRITION

It is said that everyone must grow old but not everyone need be infirm. Good nutrition is one of the factors that will extend the period of adult vitality. Although the nutritional needs of the older group have not changed materially from the needs of their earlier years, there are several reasons why the food intake and utilization may be sharply reduced in older persons. Some of the reasons given by physicians [6, 8, 10, 11] interested in geriatric medicine are:

1. The muscular tonus of the mouth, stomach, and intestines is decreased with age.

2. Appetite may be reduced because of degenerative changes in the taste buds. There may be little incentive to eat because of this decline in taste.

3. Many have inadequate and/or defective teeth. Their diets often consist mostly of soft foods—high in carbohydrate and low in protein among other dietary essentials.

4. The decreased metabolic rate and the lessened activity decreases the caloric requirement.

5. There is often diminished secretion not only of the salivary glands but also of the ptyalin content of the saliva.

6. The gastric secretion may be decreased in volume, acidity, and pepsin content. Achlorhydria is a common finding in persons over 60 years of age.

7. Digestion and absorption is frequently impaired which may increase the requirements for various dietary nutrients such as vitamins. A vitamin concentrate may be a wise addition to the diet of many aging and aged persons, the potency of which would depend in part upon the food pattern of the individual.

8. Constipation is often troublesome in older persons. This may be caused in part by their diet, but also by a diminished secretion of mucus in the lower part of the intestinal tract which normally serves as a lubricant. Mineral oil, so often used as a laxative by older persons, may interfere with the absorption of the fat-soluble vitamins.

FOOD

Nutrition problems may be difficult to handle in older persons because eating habits of a lifetime are not easily changed. They often rebel against too much restriction or too wide a change from accustomed foods. Frequently they take a diet low in protein which usually means it is also low in dietary factors associated with protein, among which are calcium, phosphorus, iron, riboflavin, and niacin. They often dislike milk which is not only an excellent source of protein but also of calcium, phosphorus, and riboflavin. "Cracking" at the corners of the mouth is a common complaint of older persons. It may be due to the type of denture materials used or it may be due to a lack of riboflavin when the intake of milk is low. Evaporated milk, whole milk (fluid or powder), skim milk (fluid or powder) may be used in *food preparation* and serve as sources of protein, calcium, and riboflavin in addition to other dietary factors. Milk does not need to be a fluid to be of value. Dried skim milk powder preparations, particularly those fortified with additional iron and vitamins, are of considerable value in the nutrition of older individuals. Several kinds of these preparations are usually available at any drug store or can be ordered by the druggist.

Cheese, including cottage cheese, lean meat, fish, and fowl are also excellent sources of protein. The controversy concerning the possible hazards of cholesterol ingestion raises the question as to the value of eggs in the diet of the aging and aged. If there is a family history of arteriosclerosis or coronary disease which may indicate that the members of the family may not handle cholesterol well, the

physician should decide the issue. Foods rich in cholesterol are egg yolk, brains, liver, kidney, oysters, sweetbreads, and various animal fats. Nuts, a palatable source of protein, may not be tolerated well by older persons especially if they are not properly chewed. Peanut butter, if one likes it, adds valuable protein among other things to the diet.

It should always be remembered that *there is no one food* which must be included in the diet. The dietary factors which a certain food contains may be indispensable, but all nutritive essentials may be secured in a number of ways as human experience has shown. In other words, there is no one system of diet or list of foods which must serve all members of the human race. Unless an individual is under the care of a physician for an illness which requires special dietary requirements, the foods given below can serve as a guide to good nutrition. Other foods to make appetizing and colorful menus should, of course, be used. Strain[12] has reported an interesting study of taste perception of nondenture wearers and of denture wearers ranging in age from 18 to 75 years. The sense of taste diminishes, as a rule, as persons grow older, so the appetite may need to be stimulated by attractive china as well as by tasty menus.

FOUNDATION DIET

The following list of foods may be termed a "basal or foundation diet": *Take daily,* if possible:

1. Milk.—One pint. (More for most children but perhaps less for some adults provided cheese or milk products are eaten regularly. Skim milk or buttermilk may be substituted if the diet contains liberal vitamin A. Evaporated milk or dry milk products may also be used.)
2. Meat, Fish, and Other Protein Foods.— One serving of meat or fish; in addition another protein dish such as cottage cheese, cheese dishes such as cheese souffle, macaroni and cheese, cheese sandwiches, etc.; or peas and beans, including soy beans, or a "made dish" using meat with cereals, vegetables, beans, cheese, etc. Inexpensive liver once a week is a good rule to follow.
3. Eggs.—One per day. If too expensive, try to have at least four per week.
4. Cereals and Breads.—One serving of whole grain or "enriched" cereal for those who like cereals; for those who do not, whole grain bread or "enriched" bread, wheat germ, brewer's yeast tablets, or other sources of additional thiamine are available.
5. One medium-size orange, one-half a grapefruit, or one (8 oz.) glass of tomato juice (undiluted); however, if other fruits and vegetables, such as apples, bananas, tomatoes, raw cabbage are available and used regularly, it is not necessary to buy oranges, grapefruit or tomato juice. There are frozen fruit juices, and canned fruit and vegetable juices on the market which are good sources of ascorbic acid.
6. Two or more servings of vegetables, aside from potatoes; preferably green and yellow ones.

7. One-half to one teaspoonful of high-grade cod-liver oil or its equivalent in vitamin D; this also supplies additional vitamin A. There are mixtures of fish oils on the market which may replace cod-liver oil; only a few drops a day are necessary. There are also tablets and capsules which may replace the oil. If an adult or child is so situated that an abundance of sunshine is available or if tuna, salmon, or other fats are eaten frequently, it may not be necessary to further increase the vitamin D content of the diet.

SAMPLE MENU

The basal diet may be expressed in a sample menu for an adult as follows:

BREAKFAST	LUNCHEON	DINNER
Grapefruit Whole grain cereal with cream 1 egg 1 slice whole wheat toast Butter or oleomargarine Coffee or tea Cream and sugar	Cream of tomato soup 2 saltines Pineapple and cottage cheese salad 1 slice whole wheat bread Butter or oleomargarine 1 (8 oz.) glass milk	Meat balls Mashed potatoes Carrots and peas Lettuce and tomato salad with dressing 1 slice whole wheat bread Butter or oleomargarine Chocolate pudding with cream Coffee, tea, or milk

(This menu can be easily altered for children who require a larger or smaller intake of food and for those adults who desire more or less food. Some adults may prefer only one glass of milk as milk. Evaporated milk, whole milk (liquid or powder), skim milk (liquid or powder) may be taken as cocoa, or in puddings, creamed soups, or creamed foods. Cheese dishes such as cheese souffle and cheese fondue are not only tasty but also nourishing foods. Milk is of value regardless of how it is taken in the diet. Details of diets must be discussed with each patient.)

These dietary suggestions are only guides; no hard and fast rules can be given in nutrition. If all aging and aged persons in the population took a diet as adequate as the menu suggested, it would still be impossible for the body's aging tissues to rebuild the skeleton, including the mandible and maxilla. What may be entirely possible, however, would be to keep the oral mucosa in a healthy condition so that the prosthodontists would not see so many water-logged tissues due in part at least to a diet low in protein, low in minerals, low in vitamins especially the B complex, and high in refined starches and sugars. Liberal ascorbic acid is also an important factor in maintaining the health of all tissues.

Many factors determine a family's food pattern, among which may be ancestry, economics, likes and dislikes, season of the year, and the time available for preparation of meals. Nothing has been said about racial food patterns but those who enjoy Chinese, Japanese, Spanish, Italian, French, German, Armenian, and other so-called foreign foods, realize how different are these food patterns from the one given you. However, all of these racial patterns and others bring about satisfactory nutrition.

Some one has said that a good prescription for the preservation of vigor into the later years of life is "Equal parts of happiness, good health, good food, good cooking,

good places to eat, good people to eat with, and good reasons for eating." If persons in the younger age groups could be convinced of the wisdom of this prescription, undoubtedly much more could be done to maintain a good skeleton, including the mandible and maxilla, than can ever be done in later years to nutritionally retrieve them.

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THE FREE-WAY SPACE AND ITS SIGNIFICANCE IN THE REHABILITATION OF THE MASTICATORY APPARATUS

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THE GREAT progress in prosthetic dentistry, source of immeasurable happiness to countless numbers requiring its services, has been largely the result of inventions and discoveries in mechanics and physics. This is in line with the renewed expectation of both medicine and dentistry that physicis will be a potent ally of the healing sciences. Our advances in prosthesis could have been enhanced, however, had we applied ourselves with equal enthusiasm to the study of the biologic sciences and their practical application in diagnosis and treatment of dental disease. For a long time, our concept of normal occlusion was based solely on a certain type of intercuspation of the natural teeth in a state of static occlusion. The objective of a prosthetic restoration was to supply the missing teeth with the same intercuspation in static occlusion. Little or no thought was given to the dynamics in function of the masticatory apparatus. We continued oblivious of the fact that the human organism, as well as every one of its parts, is continually undergoing change while in function. Since our main ultimate objective is really to restore prosthetically the masticatory mechanism in *function*, it follows then that this biologic principle should guide diagnosis and treatment planning. Our aim could then be to achieve the most approximate approach to ideal function.

At one time little attention was given to the correct determination of the maxillomandibular opening in full denture construction. It was a hit-and-miss procedure. The dentist was mostly concerned with providing adequate space for the artificial teeth between the arches. It was soon realized, however, that the improper determination of the maxillomandibular opening adversely affected the function of the dentures. The ill effect manifested itself not only in mechanics and esthetics, but in phonetics as well.

Attention then turned to facial measurements, with a view to establishing an average that would be applicable to all faces. A multitude of gadgets and devices appeared on the market with conflicting and competitive claims to superiority. While the use of facial measurements marked a step forward in prosthetics and orthodontics, their misuse frequently nullified their benefit.

For instance, it was not realized that since facial measurements are made on soft tissues, their accuracy can and should be questioned. Anthropologists are most reluctant to accept averages based on measurements in which all the landmarks

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are on soft tissues. Second, we lost sight of the fact that even the most carefully made measurements and organized averages are subject to great fluctuations and deviations—plus and minus. The variations from the average are frequently so great that it is often more harmful to use an average figure than to disregard it.

Most important of all, however, is the fact that the determination of the maxillomandibular opening is, to a great extent, work of an *imaginative nature.* Particularly does this hold true in instances where the alveolar ridges have undergone considerable bone resorption. Work of an imaginative nature, to be successful, requires considerable experience and good artistic judgment. If more time and effort were devoted in dental colleges to instruction in the essentials of art, progress in this field of our work would be greatly enhanced. The practice and experience in measuring faces constitutes good training for the development of sound artistic judgment. We learn in this way to read and interpret the significance of facial expression as related to the fields of denture prosthesis and orthodontics. However, we inevitably also conclude that averages based on facial measurements are inadequate if they are used as final criteria in establishing the maxillomandibular opening.

FREE-WAY SPACE

The reaction to this realization has recently been to turn to the free-way space as the criterion for the degree of jaw separation in rehabilitation of the masticatory apparatus. The profession should be fully aware that the validity of this latest criterion is still subject to further research, and its application is in fact in the experimental stage. Some of us have become prematurely too enthusiastic over this new approach, even to the extent of unconsciously accepting it as the final criterion. We seem to believe that all that is necessary is to accept an "average" free-way space of 2 to 3 mm. to solve the very complicated problem of the determination of the maxillomandibular opening.

Let us subject this view to a careful analysis. We assume that when we speak of a free-way space average of 2 to 3 mm. we imply a space of 2 to 3 mm. between the incisal edges of the upper and lower central incisors when the mandible is in a state of physiologic rest. Several questions arise in connection with this hypothesis.

1. Can we assume that in the majority of cases the mandible in a state of physiologic rest generally registers a 2 to 3 mm. free-way space? Neither the 2 to 3 mm. opening nor the mandible is in a position to answer this question. The dentist is equally impotent in furnishing us with this important answer. The patient is the only one who can tell us, with a certain degree of accuracy, whether or not his mandible and the adjacent and associated structures are in a state of rest at a given free-way space. The rest position of the mandible is a matter of *feeling.* And while we often believe that we can think for our patient (erroneously so), we certainly cannot appropriate his physiologic sensation of rest and strain. This axiomatic statement should be borne in our minds at all times.

2. Is the 2 to 3 mm. free-way space a really scientific average for a physiologic rest position of the mandible? We think it is not.

3. Is the free-way space a space in three dimensions or is it a space between two points which can be considered as a distance? It is neither. Instead, it should be analyzed and studied as a multiplicity of spaces that may differ greatly from one another in size, shape, and form in all three dimensions depending upon the areas selected for measurement.

For example, given a certain vertical free-way space between the upper and lower incisors, we would find the corresponding space smaller in the third molar region. This holds true (but to a lesser degree) with regard to the other two dimensions.

4. Can the free-way space be considered as a *static entity* at any time? The answer is—only in a cadaver. During lifetime the mandible is a "perpetuum mobile" and, in consequence, the free-way space is never at an absolute standstill. It varies with different orientations of the head in space; it varies with the process of deglutition; it varies with the physiologic process of respiration (it is augmented with inspiration and reduced in expiration) and, finally, it varies with different moods in our psychologic activity. It varies so much that even a two-second roentgenographic exposure cannot catch the free-way space in an absolute static position.

INTEROCCLUSAL REST SPACE

A digression for a suggestion regarding the terminology of the free-way space when the mandible is in the physiologic rest position seems to me appropriate at this point. This space is termed in Europe the "interocclusal space." In our country it is called the "free-way" space. I assume that every dentist understands these terms to be synonymous. But for a physician this nomenclature may prove very confusing. The European version, "interocclusal space," may not necessarily denote for him association with a physiologic rest position. The American version, "free-way space," may suggest to him many free-way spaces in the human body. I would, therefore, be inclined to combine the two terms into one. The "interocclusal rest space" is a more descriptive and understandable term.

However, even the more expressive designation does not lend more weight to the status of an imaginary static "interocclusal rest space." It is characteristic of the individual, depending upon the genetics and environmental conditions of his development. Great variation is also observable in direct relation to the advanced age of the patient. This has a potent and direct bearing on diagnosis and treatment planning in rehabilitation of the masticatory apparatus. Clinical experience combined with keen observation is our best teacher in dentistry. When this, in turn, is combined with open-minded experimentation and investigation we are likely to arrive at valid scientific conclusions.

METHODS OF STUDY

Four methods of investigation were employed in the study of this problem. They were (1) the clinical method, (2) measurement by means of mechanical devices, (3) roentgenography, and (4) mandibular registrations by means of extraoral needle point tracers.

CLINICAL METHOD

"An investigation of patients with average normal natural dentitions was undertaken. When these patients were placed on their backs and instructed to look straight at the ceiling, the occlusal surfaces of the opposing teeth were either in contact or nearly so. An interocclusal rest space, when present, was very small. This suggested that, in these instances, the force of gravity tended to draw the mandible in the direction opposite from that when the body was in the upright position. It was also found that when the body lay horizontally on the right side, or the left, with the head supported by a special device located in the region of the temporal muscle, the force of gravity tended to pull the mandible laterally in the same direction.

These clinical observations were made in order to measure an approximate average interocclusal rest space on subjects with natural dentitions, but this was difficult. In the first place, on carefully parting the patient's lips (when the jaws were seemingly at rest) the interocclusal rest space could be observed in the incisor region only. Any attempt to view the region of the bicuspids ended in failure, since the patient would invariably open his jaws. Unfortunately, we cannot properly observe the interocclusal rest space, even in the incisor region, unless we part the patient's lips. But just as soon as the observer touches the patient's lips, the mandible opens by reflex action.

The second handicap with this clinical approach to our study was somewhat different and of a more serious nature. Many natural dentitions have a deep vertical overlap anteriorly which frequently obscures the entire field of observation. We concluded, therefore, that direct observation and measurement of the interocclusal rest space (without fixation of the mandible) has little scientific value.

In connection with this clinical investigation, another question came to the fore. Whatever the magnitude of the interocclusal rest space may be, what is its direction? Is it formed by a rotational opening component of the mandible? Or is it the result of a combination of a rotational with a gliding component, and which of the two predominates in this combination?

Clinical observation based on visual and digital examination yielded in this instance much more positive results. A group of subjects who had edge-to-edge relationship of anterior teeth was selected for this investigation. It was found that when the mandible under observation was in a hypothetical physiologic rest position, the lower anterior teeth were in front of the upper teeth.

The technique was as follows: Two minute disks of black court plaster were attached to the skin at the extreme lateral points of the condyles, while they were in a rest position. The operator placed the tips of his forefingers in light contact with the court plaster disks. The subject was instructed to relax the mandible completely to associate it with the presence of the interocclusal rest space. When the patient was told to close from this position of rest, it was felt that the condylar heads slid upward and backward. The operator placed himself in front of the subject who was standing in an upright position, and instructed him to part his lips slightly himself with the mandible remaining in a physiologic rest. It was noticed that the mandible was in a protruded position.

This pointed to the conclusion that with the interocclusal rest space present the mandible is not exclusively confined to the rotational opening but hangs downward and forward by force of gravity. The same results were obtained when patients with average or shallow vertical overlaps were subjected to this experiment. With the interocclusal rest space present, their mandibular incisors were found in approximate edge-to-edge relation with the maxillary incisors.

If this were a strictly rotational opening component, one would have expected to find the mandibular incisors in a distal position to the upper incisors. This finding has an important bearing on the laws of prosthetic occlusion and the art and science of orthodontics.

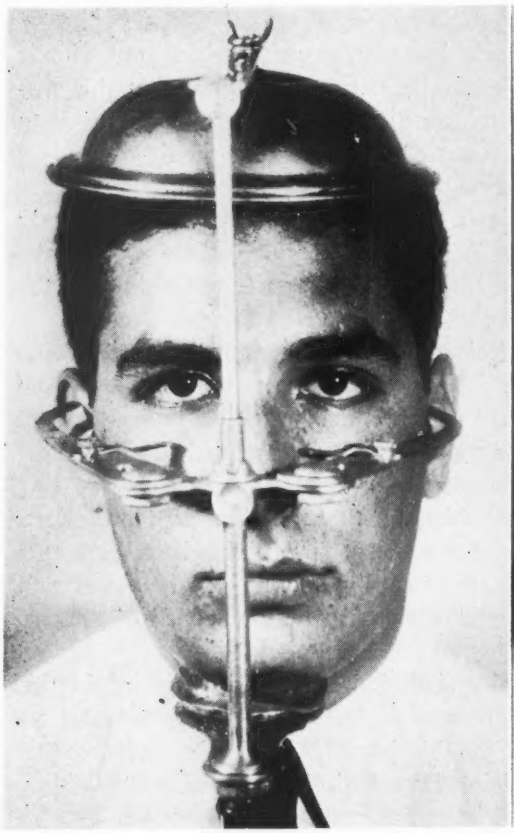

Fig. 1.

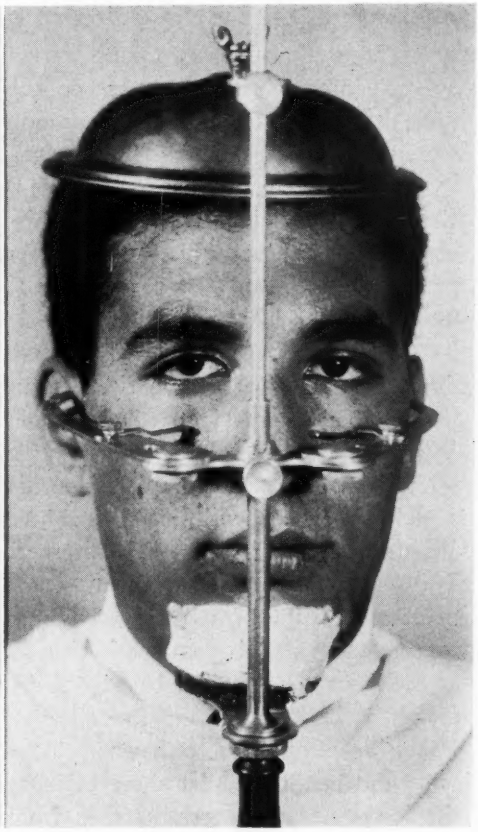

Fig. 2.

Fig. 1.—Instrument in position adjusted to head and face. Note the space between chin-tray and chin (about 1.5 cm.).

Fig. 2.—Patient in relaxed position with a free-way space between maxillary and mandibular teeth. Plaster on chin-tray to fix and maintain the mandible in this relaxed position.

MEASUREMENTS BY MEANS OF MECHANICAL DEVICES

The second approach to the study of the interocclusal rest space was by means of measurements. Two mechanical devices were used for this purpose. The first (Figs. 1 to 3) consisted of a vertical rod graduated in millimeters with a handle attached to its extreme lower end. In the middle of this rod, there was an adjust-

able vertically gliding bow that was fitted to the Frankfort horizontal plane. Above it there was a long and narrow metal blade, also gliding vertically upon the main rod and adjusted to make contact with the top of the head. This was modified by attaching to it a shallow helmet for better fixation to the head and greater stability of the instrument. Below the bow there was a flat supporting plate that was adjusted under the chin. This supporting plate had been modified by attaching to it a concave full upper impression tray that served as a receptacle for plaster. In this investigation, subjects with average normal natural dentitions were used. The

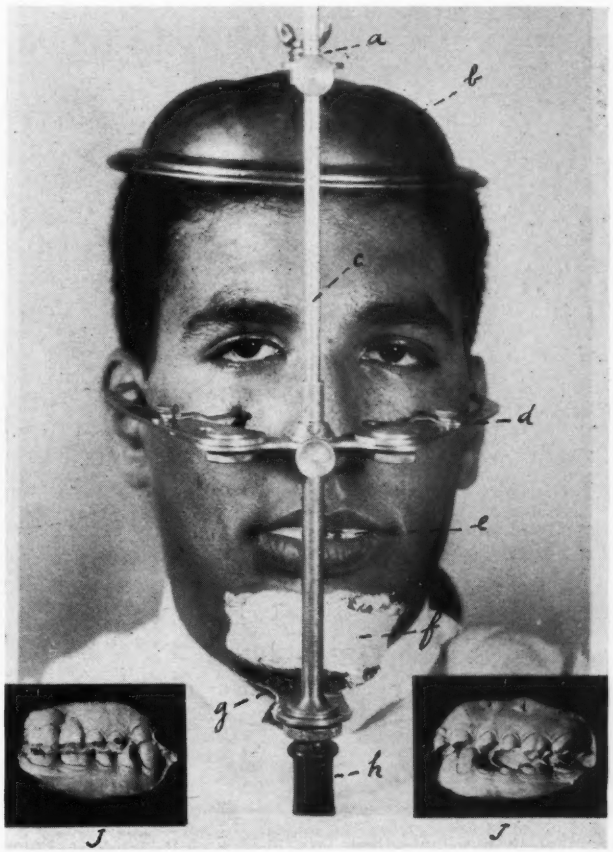

Fig. 3.—Free-way space filled with plaster on right and left side while the mandible is maintained in its relaxed position in the chin-tray.

a, Screw for attaching helmet to upper blade. *b*, Helmet. *C*, Vertical rod. *d*, Bow. *e* and *f*, Plaster. *g*, Chin-tray. *h*, Handle. *J*, Free-way space plaster patterns as seen from lingual aspect.

subjects for the experiment were one hundred teachers and students at New York University College of Dentistry. Alginate impressions of the upper and lower teeth were secured of some of these subjects as carefully as possible, and the upper cast was transferred to the articulator by means of the face-bow. Precision in this transfer is of utmost importance in this phase of the work. With the same care and precision, the mandibular cast was attached to an adjustable articulator in centric occlusion associated with centric jaw relation.

The instrument described above was then adjusted to the patient's face so as to fit the adjustable bow to the Frankfort horizontal plane. (The instrument is maintained in this position by the patient holding the handle attached to the instrument below the chin-tray.) The blade above it, with the helmet, was in contact with the top of the head, and the impression tray below was about one-half inch away from the lowest point of the chin. The patient was then instructed to relax the mandible in a physiologic rest position, and to maintain this jaw separation as carefully as possible. Soft-flowing plaster was poured into the impression tray until it completely covered the chin on its undersurface and all around. When

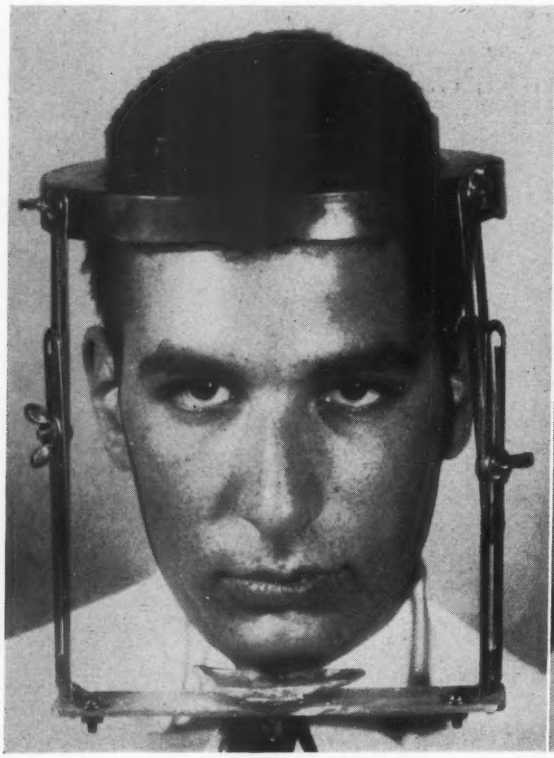

Fig. 4.

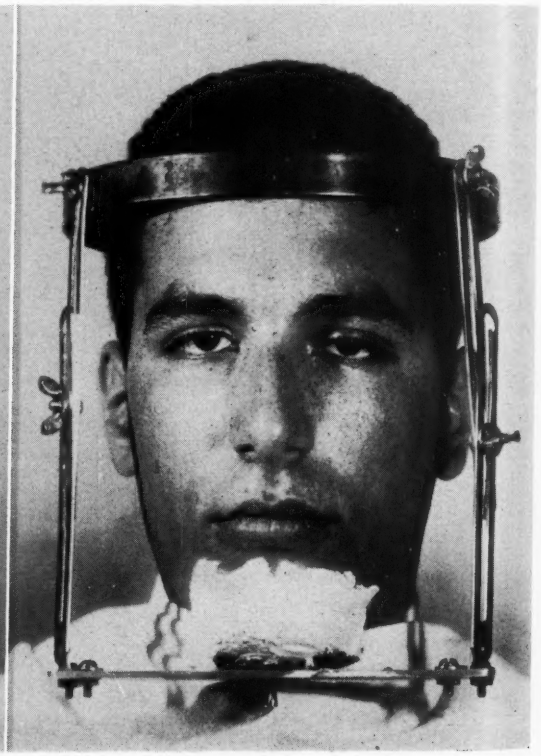

Fig. 5.

Fig. 4.—Instrument in position adjusted to head and face. Note the space between the chin-tray and chin (about 1.5 cm.).

Fig. 5.—Patient in relaxed position with free-way space between maxillary and mandibular teeth. Plaster on chin-tray to fit and maintain the mandible in this relaxed position.

this plaster crystallized, with the instrument perfectly in place, the patient's lips were carefully parted and soft plaster was injected, by means of a syringe, between the occlusal surfaces of the upper and lower teeth. Upon crystallization of the injected plaster, the instrument and the *interocclusal plaster patterns* were carefully removed from the face and mouth. The impression tray and the chin had been lined with a thin layer of petrolatum before each operation to facilitate the removal of the plaster. At this time it was possible to measure the various sections of the interocclusal plaster. The measurements obtained by this procedure presented wide variations from individual to individual.

The second mechanical device (Figs. 4 to 6) consisted of a head helmet, open on top, that could be fitted firmly to the head, and four side blades with slots superimposed upon one another and held together with wing screws, permitting the instrument to be adjusted vertically. A horizontal chin blade was attached to the side blades. On top of the chin blade was attached a concave upper impression tray (chin-tray) that could slide to the right or left side a distance of one-half inch to make it adjustable to abnormally deviated chins. The tray was shaped in a manner that, when adjusted and filled with soft plaster, it surrounded the chin to a certain depth anteroposteriorly and on the right and left sides.

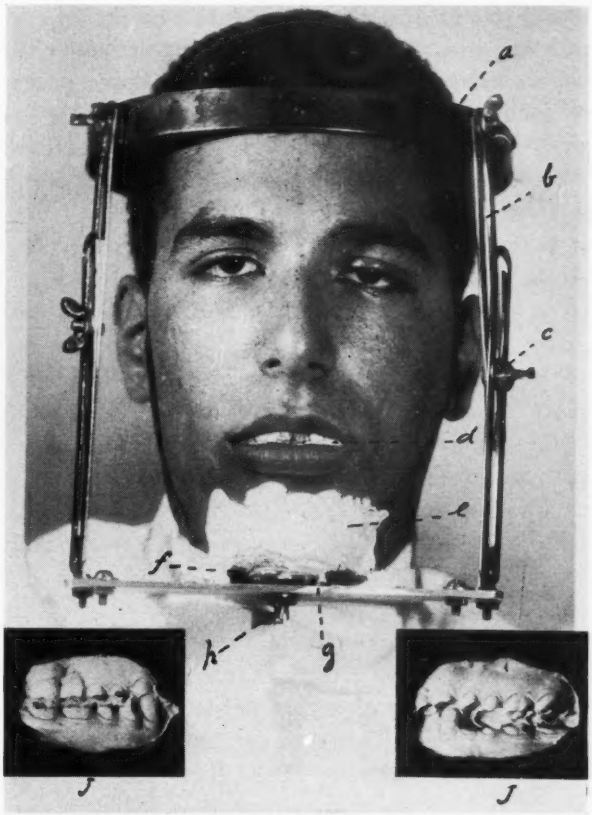

Fig. 6.—Free-way space filled with plaster on right and left side while the mandible is maintained in its relaxed position in the chin-tray.

a, Helmet open on top. *b*, Side blades. *c*, Screw. *d* and *e*, Plaster. *f*, Chin-tray. *g*, Horizontal blade. *h*, Screw. *j*, Free-way space plaster patterns as seen from lingual aspect.

The patient was instructed to relax the mandible in a state of physiologic rest. The chin-tray was adjusted to a position vertically about 1.5 cm. away from the chin, but so placed that when filled with plaster the chin should become submerged into it to a certain depth. This position is carefully maintained, the chin resting against the crystallized plaster and a newly mixed portion of plaster was injected into the interocclusal rest space. It was found more advantageous after a certain period of experimentation to introduce the soft mix of plaster into the lower portion of the vestibulum oris by means of a narrow suitable spatula, and then to

press the cheeks quickly against the teeth. In this way the plaster was made to penetrate into the interocclusal rest space.

A careful study of the interocclusal rest space plaster patterns thus obtained could then be made. It was found that these interocclusal plaster patterns could not be accommodated between the occlusal surfaces of the stone casts of the same individual when the articulator was locked in centric relation. This is not surprising since the interocclusal rest space, as previously pointed out, is not a result of a strictly rotational opening component, but represents a space formed by a combination of an opening component with a shift of the mandible downward and forward. The articulator, in this instance, only corroborated the clinical observations previously made.

On the other hand, when the adjustable articulator was fully opened for protrusive and lateral movements, the interocclusal rest space plaster patterns could not even then find for themselves precise accommodation in the interocclusal space on the articulator. This inability of the adjustable articulator to perfectly accommodate the interocclusal rest space plaster patterns suggested that the interocclusal space of a relaxed mandible is the final product of an interplay of the muscles that depress the condyles downward first, and then the mandible protrudes forward. This complex movement in various directions cannot be reproduced identically by mechanical articulators. Alginate materials were then tried with a view to facilitate the study of the behavior of the interocclusal rest space patterns. Very thin (about one-third the regular thickness) shellac perforated baseplates were used for this purpose. The latter were covered on both sides with a mix of D.P. alginate* of suitable consistency, and carefully introduced into the interocclusal rest space. After the alignate had set, it was found that these interocclusal patterns could be easily fitted into the space on the articulator when the latter was opened for lateral and protrusive movements. The readings on the articulator interpreted the interocclusal rest space to represent a combination of an opening component associated with a protrusive component with an admixture, in some instances, of a slight lateral component.

An interocclusal rest space, therefore, is a conceptual scheme of a particular and peculiar degree of jaw separation that exists in a given individual when his mandible is completely relaxed. This space cannot be incorporated into an articulator correctly in a perceptual manner. The belief that the free-way space represents a strictly rotational opening component of the mandible is questionable. What it actually represents is, first, a disengagement of the condyles from the glenoid cavities in a downward direction. This is effected by the interplay of a group of muscles that are best suited for this particular displacement of the mandible. The subsequent second movement of the mandible in a forward and downward direction is effected by the force of gravity. The slight lateral component, when present, is probably also occasioned by force of gravity.

DYNAMICS OF THE INTEROCCLUSAL REST SPACE

For a clear understanding of the dynamics of the interocclusal rest space, three phases or cycles involved in it require study. These are (1) its formation, (2) its maintenance in a *relatively* static state, and (3) its closure.

*Dental Products Co., Chicago, Ill.

Let us start with the static intercuspation of the teeth. In order to form the interocclusal rest space, the cusps must become disengaged from their state of interdigitation and the condyles must slip out correspondingly from their most retruded and deepest position in the glenoid cavities. This is effected by an *active* descent of the mandible in a downward direction. It is followed by a *passive* movement of the mandible downward and forward by the force of gravity until it assumes a *relative* state of equilibrium.

Its maintenance in this state depends upon the orientation of the head in space. Thus, if the head is oriented downward, the mandible tends to close, and the interocclusal rest space is reduced. If the head is oriented backward, the mandible passively falls backward and the interocclusal rest space becomes perceptibly smaller. The space is maintained at its optimum in a relative state of equilibrium when the head is oriented in such a manner that the Frankfort horizontal plane is parallel to the floor or nearly so.

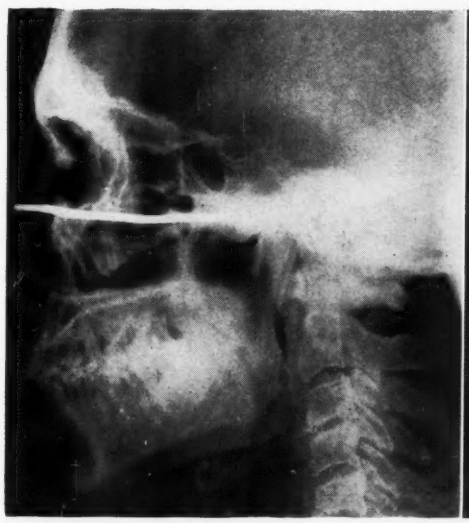

Fig. 7.

Fig. 8.

Fig. 7.—Head in an upright position. Mouth closed in unstrained centric occlusion. Frankfort horizontal plane passing through the uppermost portion of the tragus and the lowest point on inferior border of the orbit (metal rod) is parallel to the floor. Note the retruded position of the lower anterior teeth and condyle in centric relation.

Fig. 8.—Head in upright position. Mandible at rest with interocclusal rest space between the upper and lower teeth. The Frankfort horizontal plane is parallel to the floor. Note the protruded position of the condyle and the anterior teeth. This is not a rotational opening component but an opening associated with protrusion brought on by the force of gravity.

When the subject undergoing experimentation was flat on his back with eyes directed at the ceiling, the mandible passively fell back and the interocclusal rest space became considerably reduced. When the subject reclined on his back with the head hanging downward by force of gravity over the edge of the table, the occlusal surfaces of the teeth effected almost continuous contact. When the same person was suspended by his legs and the head oriented in a manner that the Frankfort horizontal plane was parallel to the floor, the interocclusal rest space became completely obliterated with the original intercuspation re-established.

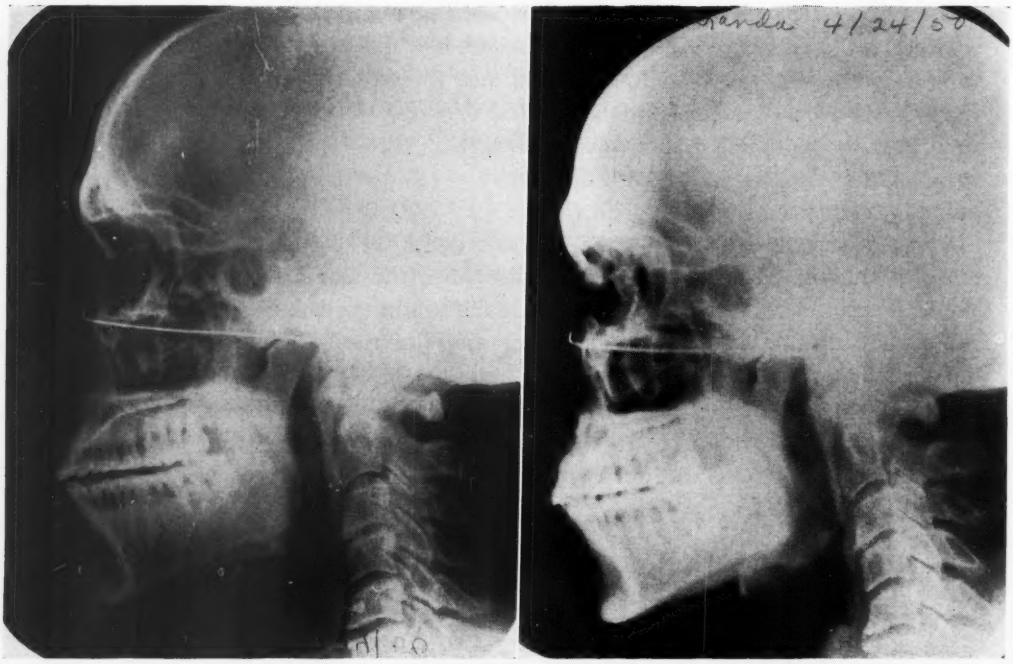

Fig. 9. Fig. 10.

Fig. 9.—Head in upright position. Mouth open at rest with an interocclusal rest space. Note the protruded position of lower incisors and condyle.

Fig. 10.—Head in upright position with the Frankfort horizontal plane parallel to the floor. Mouth closed in unstrained centric occlusion. Note the retrusion of the condyle and teeth in this position.

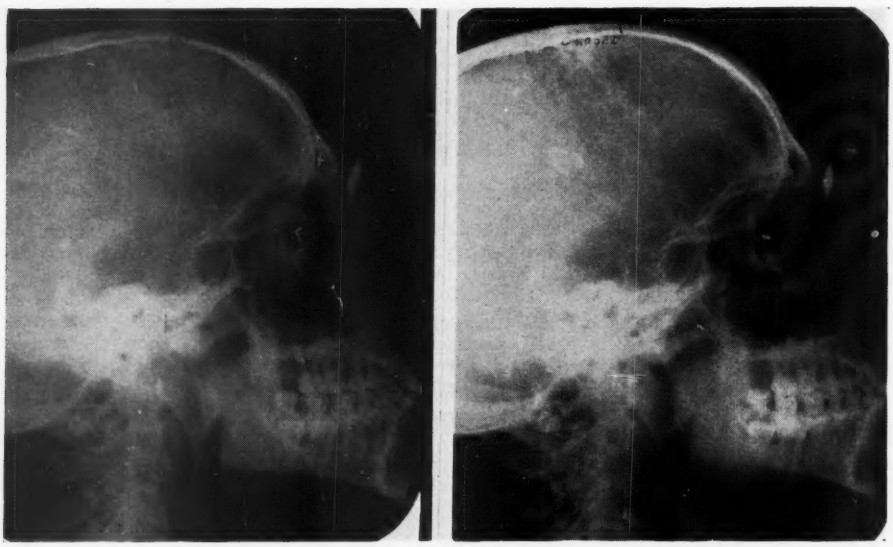

Fig. 11. Fig. 12.

Figs. 11 and 12.—Mandible in a state of rest. Patient on his back in a horizontal position with his eyes directed at the ceiling. Note the relationship between the maxillary and mandibular teeth with an insignificantly small interocclusal rest space.

ROENTGENOGRAPHIC STUDY

A careful roentgenographic study of the interocclusal rest space confirmed the clinical observations in this investigation. A Ritter x-ray machine was used. The rays were directed perpendicularly to the face at a distance of 36 inches with a two-second exposure. In securing these roentgenograms, utmost care was taken to keep the patient in a comfortable position that would enhance complete relaxation of

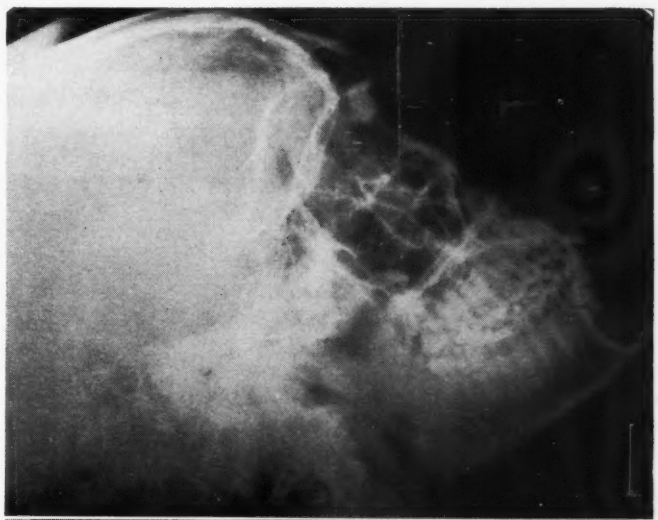

Fig. 13.

Fig. 14.

Fig. 13.—Patient on his back in a horizontal position with his head hanging down over the edge of a table. Note the absence of an interocclusal rest space.

Fig. 14.—Patient on his back in a horizontal position with his head hanging down over the edge of the table. Note the absence of an interocclusal rest space.

his mandible. Slight superimposition of anatomic structures observed in these series were of no serious consequence to this project, considering the fact that no measurements of the free-way space on the roentgenograms were at all contemplated. Such

measurements would be of little value since the fixation instrument for the mandible could not be used for the various positions of the body in this study. An examination of the roentgenograms, however, does show considerable variations in the free-way space with different orientations of the body and head. This confirmed our clinical observations previously arrived at. Thus the free-way space was at its optimum when the body was in an upright position with the Frankfort horizontal plane parallel to the floor (Figs. 7 to 10). The free-way space was very small when the subject reclined on his back with eyes directed straight upward at the ceiling (Figs. 11 and 12). The free-way space became still smaller by the force of gravity when the subject reclined on his back, with his head hanging downward over edge of a table (Figs. 13 to 15).

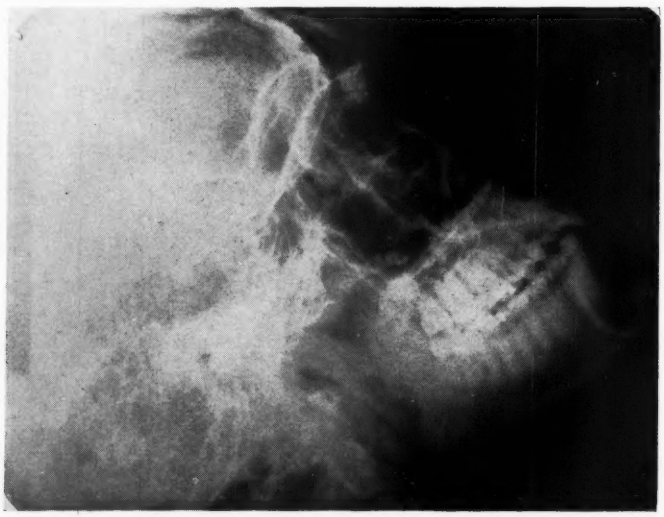

Fig. 15.—Patient on his back in a horizontal position with his head hanging down over the edge of a table. Mouth slightly open. Note the rotational component with retrusion of mandible.

This led us to the conclusion that the interocclusal rest space is never absolutely static, but can be so only in a relative sense of the word; that is, when the head is oriented properly and the patient and his jaw are in a complete state of relaxation. But, as was previously indicated, mere visual observation of this space by parting the patient's lips is inadequate because it immediately disturbs the state of equilibrium of the mandible. Measuring the free-way space by means of fixation of the mandible in a relaxed position as described in this technique is by far more scientific. The mean thus obtained from one hundred measurements is equal to 3.07 to 3.67 mm. (See Statistical Analysis).

MANDIBULAR REGISTRATION BY MEANS OF EXTRAORAL NEEDLE POINT TRACERS

For this purpose we can use the Gysi Gothic arch tracer, the Sears', Trivet, the Hight tracer, McCollum's mandibular registration devices, or the Stansbery tracer. The last named represents an extraoral tracing in combination with an intraoral central bearing point. The central bearing point is the point of a screw that is

adjustable in the middle of a triangular plate. The latter is attached to the lower occlusion rim in such a way that the screw corresponds to the center of the mandibular ridge. The upper flat metal plate is attached to the upper occlusion rim in such a way that the upper point of the lower screw contacts it at a point approximately corresponding to the center of the vault. This single central bearing point unifies the pressure upon the upper and lower rims, and in this manner stabilizes them while the tracing registrations are being made. To these bearing plates are attached anteriorly, by brackets, the upper stylus and the lower tracing plate for Gothic arch registrations. The brackets are rather long and that in turn magnifies the tracing registrations making them easy to read and interpret.

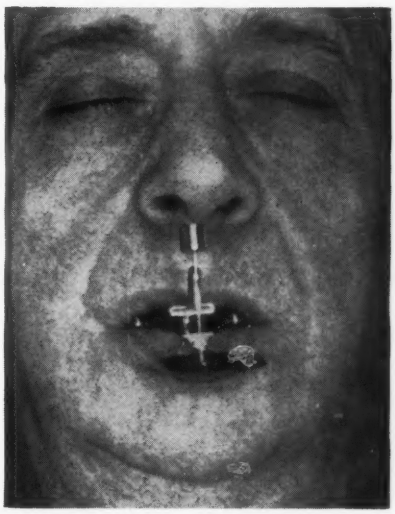

Fig. 16.—Extraoral needle point tracer showing slight protrusion of the mandible associated with the interocclusal rest space.

An investigation conducted on patients in the process of full denture construction revealed that the free-way space was formed by a combination of an opening with a protrusive component. After the correct vertical dimension had been fixed by means of the central bearing point, the lower tracing plate was covered with lamp black or camphor smoke and the patient was instructed to close in centric relation and maintain that position. The stylus was then inserted into the upper bracket, and it fell by its own weight into a certain point on the tracing plate. This point may be designated as the centric jaw relation registration. The patient, experienced by previous practice, was then instructed to carefully relax the mandible to a physiologic position of rest. The resulting registration on the tracing plate showed a protrusive movement associated with the particular interocclusal rest space (Figs. 16 to 21).

Similar results were obtained in a study of subjects with average normal dentitions. In this study, I used a tracing device of my own design. The latter was securely attached to the labial and buccal surfaces of the upper and lower teeth so that the patient did not experience any interference in closure into centric occlusion

associated with centric jaw relation. The interocclusal rest space registration was then obtained by the same technique as in full denture construction described above.

When we speak of relaxation of the mandible in the presence of the interocclusal rest space, it does not denote *absolute* rest of the masticatory muscles. In-

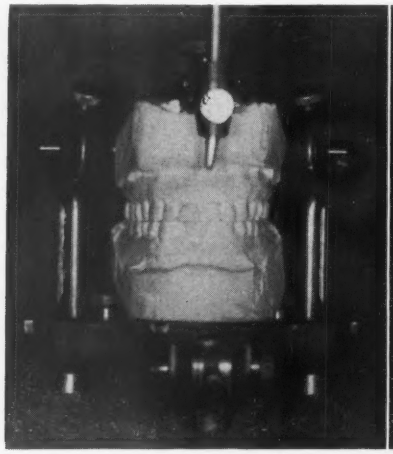

Fig. 17.

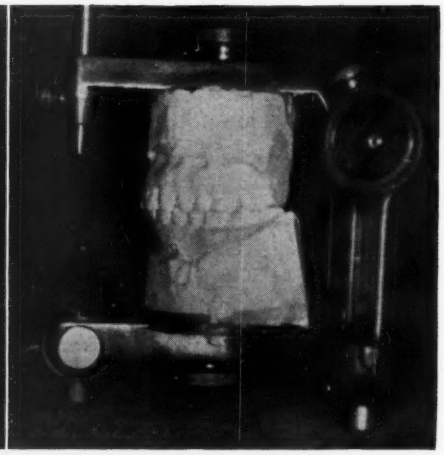

Fig. 18.

Fig. 17.—Front view of casts attached to articulator in centric occlusion.

Fig. 18.—Lateral view of the same casts attached to articulator in centric occlusion.

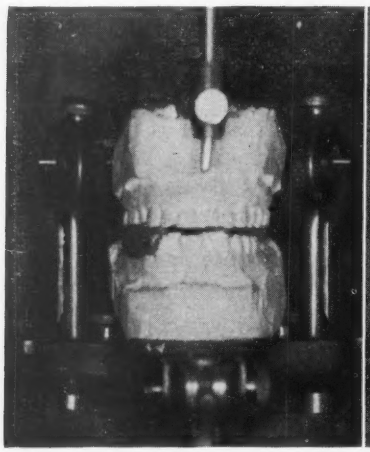

Fig. 19.

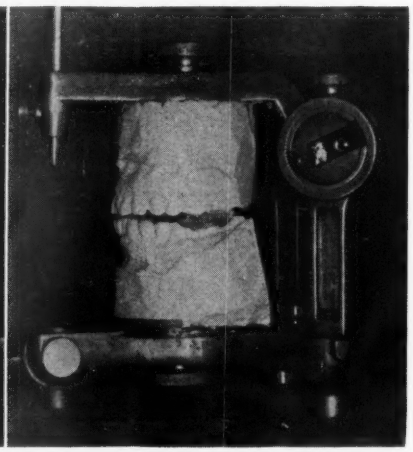

Fig. 20.

Fig. 19.—Front view of the same casts with interocclusal rest space plaster patterns between them showing protrusion of the mandible.

Fig. 20.—Lateral view of the same casts with interocclusal rest space plaster patterns between them showing protrusion of the mandible.

deed, a certain amount of muscle tension must be present in the muscles to overcome the force of gravity to which the mandible is constantly subjected. The afferent and efferent stimuli that govern the particular tension of the masticatory muscles at a given time have for their objective the establishment of an active state of equilib-

rium in which the tension of the muscles must counterbalance the force of gravity. The latter is dependent upon the postural position of the head to which the mandible is attached. This should guide our thinking when we are engaged in research, and also when we are seeking solutions to everyday clinical problems. The spatial orientation of the head of the patient while securing jaw relations for full denture construction is still a controversial subject in our profession. This is because we are still befogged by the old concept of muscle activity based on a study of individual muscles in isolated action. The magnitude of the force of an isolated muscle, its direction and distribution are epitomized as if they were physical phenomena, whereas in reality they represent the most delicate and complex biologic muscular interplay and interaction. We may go as far as to state that even in simple opening of the jaws or with a simple protrusive movement all the muscles of mastication participate simultaneously, some in a synergistic manner, others by divergent

Fig. 21.—Horizontal Condylar indication of articulator showing the amount of protrusion in Figs. 19 and 20.

action. Moyers[1] has made a distinct contribution to dentistry and opened new avenues for dental research. When the instruments and techniques used are simplified and perfected, electromyography will become a potent ally of dental science in all its branches. It will help to clarify the meaning of the concept: the *rest* relation as contrasted with the *strained* relation of the mandible to the maxilla. "Rest" and "strain" are a matter of degrees, and there is no definite line of demarcation to show clinically where the strain of the muscles of mastication ends and where absolute rest begins. Electromyography may go a long way in shedding light on this subject and in this way further our understanding of the function of the masticatory mechanism in health and disease. It, indeed, already has made notable contributions in this direction. Yet there are still blank areas in our knowledge of oral physiology. One of them is the interocclusal rest space that is in need of further research and investigation.

In the light of our present knowledge, the average of 3.07 to 3.67 mm. seems to be scientifically valid. Nevertheless, I would not advocate its use as the exclusive criterion for oral rehabilitation. The reason is that the fluctuations plus and

minus from this average are extensive. The interval of 4.4 mm is larger than the mean of 3.07 to 3.67 in our study (see Statistical Analysis). We must conclude, therefore, that the maxillomandibular opening cannot be determined by an average applicable to all individuals but must be established on a *functional* basis for each and every patient under treatment. We must bear in mind that the vertical dimension we are seeking to establish is really an unknown quantity. We can consider two kinds of vertical dimensions. (1) The mouth is closed with the teeth in a state of intercuspation, and (2) the mouth is open, teeth are parted with the mandible hanging downward by force of gravity in a relaxed position. The first is called the *active* vertical dimension. The second is the *passive* vertical dimension. The free-way space can then be expressed by the following equation: Passive vertical dimension *minus* active vertical dimension *equals* free-way space, or interocclusal rest space.

Let us subject this formula to a careful analysis and turn to biologic function as the important criterion. In many instances, vertical overlaps with allegedly insufficient active vertical dimensions have rendered excellent service for nearly a lifetime to people "afflicted" by it. Of course, we do not know what might have happened to these individuals had their vertical dimensions been increased by so-called "bite raising" procedures. But the criterion of biologic function speaks for itself. We must be mindful of the fact that whether a vertical overlap is attributable to an underdevelopment of the posterior teeth, an overdevelopment of the anterior teeth or both, it is usually not an accident but the result of a definite process of development of the individual. By a process of development we understand all the internal and external environmental influences, physical, biologic, and psychologic, that an individual was subjected to from birth up to the time when he appeared for treatment. Anomalies resulting from a particular and peculiar process of development may be corrected by the orthodontist only when diagnosed at a very early stage. The treatment established must be on a broad basis, both in scope and thoroughness, and must include a change in the environmental milieu. Patients calling at the prosthodontist's office for mouth rehabilitation are usually way past the formative stage. The developmental anomaly has by this time become an integral part of the biologic and psychologic pattern of the individual. "Bite raising", except for certain selected cases, may prove harmful because it would be directed at the effect rather than at the cause of the anomaly. It follows then that whenever a prosthodontist or general practitioner is confronted with what he considers an insufficient vertical dimension of a natural dentition, in which all or most of the teeth are present, no "bite raising" procedure should be undertaken unless an orthodontist and periodontist have participated in a consultation. Should it be concluded that treatment is desirable, a decision must be made as to whether it should be treated by orthodontic or prosthetic means, or both. If it is found that the temporomandibular joint, the bone pattern, as well as the periodontal structures, are in a state of health that would permit augmenting the vertical dimension, orthodontic rather than prosthodontic procedure may be the treatment of choice. In either case, the restoration of proper function is the ultimate goal. It is impossible to maintain good esthetics for any length of time unless proper function of the masticatory apparatus is assured.

This holds true in the field of full denture construction and orthodontics, as well as in full mouth rehabilitation by means of fixed or removable bridgework. To re-establish function by means of oral prosthesis implies: (1) planning the treatment in such a manner that health and comfort are derived from the artificial restoration during the process of mastication; (2) the patient must be comfortable in speaking, with no impediment in phonetics, and (3) the patient's esthetic appearance must be restored to its optimum.

It is understood that situations arise in which minor compromises are inescapable among these three features in certain restorative procedures. The objective of such compromises is optimum *function* of the restoration from a point of view of the health service it is required to render.

A test for the correctness of a given maxillomandibular opening from the standpoint of mechanical efficiency is best provided by eliciting information from the patient with regard to his own tactile sense. For this purpose, the patient is instructed to bring the occlusion rims tightly together and to report whether it is *his feeling* that at this particular height of occlusion he could masticate his food with comfort. The degree of jaw separation may then be slightly augmented or reduced in accordance with the patient's feeling in the matter. Several changes in the height of the occlusion rims may have to be made until the patient experiences optimum comfort. The same tests are performed with the teeth set up in hard wax, except that the patient is instructed to bring the teeth together lightly. At this time the patient is asked to indicate whether the meeting of the opposing masticatory surfaces at this particular height would, according to his tactile sense, supply him with maximum mechanical efficiency. Changes may also have to be effected at this stage in accordance with the patient's tactile physiologic responses. These dynamic manifestations of the changes in tactile sensations concurrently with corresponding changes in the vertical dimension are revealed to us by the patient as he perceives them. Proper interpretation by the operator of these subjective tactile responses of the patient is extremely helpful in establishing the correct maxillomandibular opening.

The second feature of great moment in the determination of the vertical dimension is the phonetic test. Given a set of stable dentures upon their supporting structures, clattering of the teeth with the pronunciation of the "S" sound is a definite indication of an excessive vertical dimension. On the other hand, when the "S" resembles the "SH" sound, with an admixture of a slight whistling, it is suggestive of an insufficient degree of jaw separation. The ease or difficulty with which the letter "M" is pronounced with the artificial dentures, and the interocclusal rest space formation that follows it, is another valuable aid in full denture construction. We might say, in a general way, that a great number of individual sounds and their various combinations are extremely helpful in the determination of the correct vertical dimension. This pertains to the practice of orthodontics as well. This fact is sufficient to emphasize the extreme importance of the subject of phonetics to dentists. I am certain that we all recognize with regret that our profession has not been sufficiently mindful of this important phase of dentistry.

The third important (probably the most important) feature to be utilized in the determination of the vertical dimension is the esthetic appearance of the patient. The operator's keen observation reinforced by an artistic sense of judgment of esthetic values are his most important armamentarium in the practice of oral rehabilitation. Lavater says, "The mouth is the interpreter of the mind and of the heart. It combines, both in a state of rest and in the infinite variety of its motions, a world of characters. It is eloquent even in its silence." To restore a lost facial contour to its natural appearance a dentist must be a scientist and an artist.

CONCLUSIONS

1. The generally accepted 2 to 3 mm. free-way space is found wanting when subjected to a careful study by means of measurements.
2. The free-way space is not engendered singly by an opening component of the mandible but represents a combination of an opening with a protrusive component.
3. The free-way space cannot be used as the only criterion for the maxillomandibular opening.
4. A slight overclosure of the mandible in oral rehabilitation procedures is always to be preferred to excessive jaw separation.
5. The average free-way space arrived at in this investigation was equal to 3.07 to 3.67 mm.
6. Averages cannot be used as therapeutic agents in dentistry, but can serve only as a point of departure for individualization of cases under treatment.
7. The free-way space is effected first by a disengagement of the condyles from the deepest portion of the respective glenoid cavities, followed by a movement of the mandible downward and forward by force of gravity.
8. The complex architectural structure of the free-way space cannot be incorporated into an articulator.
9. Increasing or decreasing the jaw separation in complete mouth rehabilitation is strictly a chair procedure, and cannot be dealt with in the laboratory.
10. The state of health of the temporomandibular joint structures, the neuromuscular reflexes of the masticatory mechanism, and the habitual postural position of the head and mandible should be taken into consideration in the determination of the vertical dimension of an individual case under treatment.

MEASUREMENTS AND STATISTICAL ANALYSIS

A list of observations was made of one hundred individuals. The subjects for the experiment were teachers and students at the dental college of New York University. Only one subject was a woman. The observations included a measurement of the interocclusal rest space in three different areas of the mouth, done both on the right and left sides in each instance. The areas measured were: (1) Area of the first premolar, buccal cusp; (2) area of the first molar, central fossae, and (3) area of the second molar, buccal cusp.

A tabulation of the measurements taken is shown in Table I.

TABLE I

CASE (NO.)	AGE (YEARS)	FIRST BICUSPID AREA (DISTANCE BETWEEN BUCCAL CUSPS)		FIRST MOLAR AREA (DISTANCE BETWEEN CENTRAL FOSSAE)		SECOND MOLAR AREA (DISTANCE BETWEEN BUCCAL CUSPS)	
		RIGHT (MM.)	LEFT (MM.)	RIGHT (MM.)	LEFT (MM.)	RIGHT (MM.)	LEFT (MM.)
1	38	2.8	3.0	4	3.6	3.0	2.5
2	24	2.0	3.0	3.4	4.0	—	4.4
3	35	1.5	1.5	2.0	1.4	—	1.5
4	26	3.8	4.0	3.5	4.9	—	3.0
5	33	6.8	7.5	7.0	7.1	—	6.5
6	45	1.5	2.8	3.4	2.5	1.8	2.2
7	33	2.5	3.0	2.8	4.0	2.0	2.8
8	29	4.0	3.6	3.6	3.5	1.2	2.4
9	28	2.0	1.2	2.5	2.5	2.3	3.0
10	35	4.0	3.0	3.0	4.5	2.0	3.0
11	31	3.2	7.5	5.8	6.2	4.2	6.8
12	40	3.0	4.2	4.0	3.4	3.5	3.4
13	24	2.2	3.2	3.4	3.0	1.8	2.5
14	46	1.1	1.1	2.0	1.1	3.0	0.9
15	22	1.2	2.2	3.8	4.0	2.5	2.8
16	30	6.2	6.1	3.5	3.5	6.9	5.5
17	37	3.0	2.0	2.0	1.7	1.5	1.8
18	31	3.0	2.8	2.5	1.8	2.0	1.4
19	28	5.2	5.5	4.5	5.0	4.0	4.5
20	28	3.5	—	1.5	—	0.9	—
21	27	2.0	2.0	3.0	2.0	4.0	1.5
22	27	6.4	2.0	3.5	4.0	2.0	2.0
23	25	2.2	3.0	1.6	1.8	1.0	1.9
24	39	4.0	4.0	5.8	4.5	3.4	4.0
25	34	2.8	3.8	3.2	2.8	3.0	1.8
26	27	3.0	4.0	6.0	7.0	2.5	2.5
27	24	5.0	4.5	5.0	5.5	4.8	5.0
28	38	3.0	2.5	2.1	3.0	2.0	2.0
29	25	6.0	6.2	6.0	7.0	5.0	6.4
30	45	5.0	5.5	6.1	6.2	3.0	3.0
31	32	2.5	1.5	2.2	4.5	2.0	2.0
32	32	2.0	1.5	1.5	2.0	3.0	1.5
33	27	3.5	3.0	4.6	4.0	2.8	3.1
34	24	5.0	4.0	5.8	4.0	2.4	3.0
35	26	3.0	5.5	5.0	3.2	3.0	3.5
36	32	6.2	8.0	8.0	7.5	5.0	6.0
37	25	1.5	1.5	1.5	1.0	2.0	2.0
38	32	6.1	7.0	6.2	7.0	4.5	6.0
39	25	2.1	2.0	2.0	1.8	2.0	2.0
40	25	3.5	3.0	2.5	2.5	3.0	2.5
41	23	4.5	5.1	3.1	6.1	—	3.5
42	33	4.9	3.8	5.7	4.1	2.5	3.2
43	26	1.1	1.2	0.6	1.5	0.5	0.9
44	18	2.0	1.2	1.5	1.5	—	1.5
45	24	3.2	2.1	3.8	3.5	2.3	2.0
46	22	3.0	3.0	3.8	4.1	3.0	2.5
47	27	2.2	2.8	4.0	3.4	2.6	2.5
48	41	3.1	3.4	4.0	3.4	3.4	2.0
49	35	4.0	4.1	5.9	4.9	3.3	3.0
50	27	1.9	2.1	1.0	1.5	0.9	0.6
51	35	3.4	4.9	5.0	4.9	3.6	2.8
52	32	7.3	5.0	—	7.2	6.4	5.2
53	43	3.0	3.0	2.8	2.1	2.2	1.9
54	30	6.1	2.8	4.0	3.4	5.4	5.9
55	25	3.4	3.2	3.4	4.5	3.4	2.1
56	28	5.0	4.5	4.5	4.0	3.4	3.6
57	27	5.0	6.8	3.8	6.2	3.0	—

TABLE I—Continued

CASE (NO.)	AGE (YEARS)	FIRST BICUSPID AREA (DISTANCE BETWEEN BUCCAL CUSPS)		FIRST MOLAR AREA (DISTANCE BETWEEN CENTRAL FOSSAE)		SECOND MOLAR AREA (DISTANCE BETWEEN BUCCAL CUSPS)	
		RIGHT (MM.)	LEFT (MM.)	RIGHT (MM.)	LEFT (MM.)	RIGHT (MM.)	LEFT (MM.)
58	32	2.5	3.4	2.6	3.1	2.0	1.5
59	37	3.0	2.9	4.0	3.5	2.5	—
60	23	6.9	6.5	6.2	6.5	—	5.1
61	29	5.0	6.6	5.6	6.1	3.0	4.2
62	31	2.2	1.6	2.0	2.1	1.5	1.9
63	27	4.5	3.7	5.0	3.0	2.5	1.7
64	22	4.2	4.5	5.0	4.0	4.6	3.9
65	24	6.0	6.6	6.0	6.4	6.0	—
66	23	2.8	1.7	5.6	5.1	5.2	4.9
67	29	5.1	3.6	5.0	4.5	3.4	5.1
68	28	2.5	2.6	2.0	2.1	2.4	2.0
69	25	3.2	3.4	3.0	—	—	—
70	59	4.1	3.0	3.1	3.0	2.5	—
71	29	2.0	—	1.6	—	1.4	—
72	31	3.1	4.0	3.7	3.5	3.0	—
73	25	3.5	5.4	4.0	4.5	3.4	4.0
74	30	3.0	3.2	4.0	4.1	2.9	—
75	22	4.2	5.6	4.5	5.1	4.9	5.0
76	24	3.1	3.5	2.3	2.6	0.9	2.4
77	28	4.4	5.5	8.1	6.4	—	4.8
78	27	4.5	3.8	3.6	3.8	2.6	3.0
79	24	4.4	3.8	3.6	3.0	—	—
80	25	3.0	1.5	2.3	2.6	2.4	3.7
81	28	1.8	1.7	1.8	2.0	1.9	1.8
82	23	3.0	3.2	4.0	4.3	4.9	4.8
83	26	1.2	2.4	0.5	0.9	1.8	2.5
84	25	2.0	2.0	3.7	1.8	1.5	2.0
85	27	2.9	1.0	3.3	1.6	2.9	0.8
86	27	2.5	3.9	1.6	2.0	2.0	—
87	27	4.5	3.4	5.5	4.2	3.4	3.5
88	—	0.9	2.0	1.1	1.4	1.3	2.3
89	23.5	2.9	4.8	3.0	4.5	3.8	4.0
90	25.5	3.9	3.0	7.0	5.4	4.0	—
91	26	2.0	2.0	3.2	2.6	2.4	2.0
92	23	2.0	3.4	4.4	3.9	3.8	3.0
93	29	2.5	2.0	5.5	5.5	3.5	2.0
94	27.5	—	1.5	—	1.3	—	1.6
95	30	5.2	4.6	4.4	4.6	—	3.8
96	26	2.0	4.4	2.8	3.0	2.0	4.0
97	26	2.0	2.4	2.4	3.2	3.0	2.5
98	23	2.0	2.2	2.0	1.4	3.0	2.0
99	23	1.4	2.0	2.0	1.4	1.4	2.9
100	31	2.6	1.0	3.6	2.5	2.7	2.2
Total		334.9	339.0	361.9	358.1	255.3	266.7
No. of observ.		99	98	98	97	88	88
Average		3.38	3.42	3.69	3.69	2.91	2.99
Variance		2.2	1.7	2.3	3.2	1.6	2.1

STATISTICAL ANALYSIS

From Table I obtained by our technique, we have computed the average values of the opening in millimeters.

We can see that these computations have been done for the right and left sides of the mouth, and in three distinct areas.

Our first tests were done to determine if there was any significant difference between the values for the right and left sides of each area. To accomplish this we used the following test:

$$t = \frac{\sqrt{\frac{n_1 \quad n_2}{n_1 + n_2}}\left(\bar{X}_1 - \bar{X}_2\right)}{\sqrt{S}} = \frac{\sqrt{0.02}\ (0.04)}{\sqrt{1.99}} = \frac{0.041}{0.2005}$$

$$S = \frac{\Sigma_1\ (X_{1i} - \bar{X}_1)^2 + \Sigma_1\ (X_{2i} - \bar{X}_2)^2}{n_1 + n_2 - 2} = \frac{390.6}{195} = 1.992$$

Where $\bar{X}_1$ = Average value of right side of first area.
$\bar{X}_2$ = Average value of left side of the first area.
Σ = Summation sign.
X_{1i} = Each individual measurement of the first area right side.
X_{2i} = Each individual measurement of the first area left side.
n_1, n_2 = The number of measurements for the right and left sides of the first area.

Applying this test, we found that there was no significant difference between the right and left side in each of the three areas measured. This serves two purposes, the first is that in future tests with the same technique we need measure only one side, and secondly, it serves us as a check as to the precision of the technique.

We next applied Bartlett's test for homogeneity of the variance. This was to compare the amount of variation in the results of the three areas and to determine if it would be beneficial, and significantly so, to use any one area as superior to the other two, from which to take the measurements (if one area would afford greater precision of measurement than the other two). The test indicated that the three areas are not significantly different in variation and that in future tests with the same technique any one area may be used.

We have thus far determined that each of the three areas is equally precise for measuring the opening, and that we may select the right or the left side of any one area as the point from which to measure the opening. For the sake of convenience we selected the right side of the bicuspid area to measure the interocclusal rest space.

It would be gratifying to be able to say that the interocclusal rest space is from 3.07 to 3.67 mm. But since we have only 99 measurements at this point we can only estimate the distance. Since we are estimating a distance, we must attach a probability to our estimate. To do this we substitute our values in the following formula:

$$P\left[\bar{X} - t_{.05}\sqrt{\frac{\Sigma_1 (X_i - \bar{X})^2}{n\ (n-1)}} < U < \bar{X} + t_{.05}\sqrt{\frac{\Sigma_1 (X_i - \bar{X})^2}{n\ (n-1)}}\right] = 95\%$$

$$P\left[3.38 - 1.96\sqrt{\frac{(221.6)}{(98)\ (99)}} < U < 3.38 + 1.96\sqrt{\frac{(221.6)}{(98)\ (99)}}\right] = 95\%$$

$$P\ [3.07 < U < 3.67] = 95\%$$

$\bar{X}$ = the average value
$t_{.05}$ = the student's t for .05
X_i = observed value
n = the number of observations
Σ_1 = the summation
U = the estimated true mean

We thus arrive at an estimate of the true average distance. Our estimate takes the form of an interval, and we can say that the chances are 95 per cent that the average distance between the first premolars on the right side during rest and in the position (vertical) as measured is between 3.07 and 3.67 mm. This does not mean that in people selected at random the measurements will fall in that interval, but that the over-all average of the whole population will fall in the interval; the chance of this occurring is 95 per cent. To illustrate this further we have estimated the sample range. A formula is used for the dispersion about a sample mean in a normal population.

We have estimated the 68.27 per cent range from our sample. From this we can now conclude that the chances are about 68 per cent that the next measurement taken will fall in the interval of 1.18 to 5.58 mm. This is quite a large interval, 4.4 mm., and it is even larger than the mean obtained from our observations. This indicates that to use the estimated mean of 3.07 to 3.67 mm. in a therapeutic capacity would lead to difficulties, inasmuch as most of the readings would be outside this interval.

My thanks to Dr. Arthur Raeder for assisting with measurements of the interocclusal plaster patterns and to Dr. Harold Katz for assistance with statistical calculations.

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PRESENT CONCEPTIONS OF THE MOVEMENTS AND FUNCTIONAL POSITIONS OF THE HUMAN LOWER JAW

An Articulator Construction Based on These Principles

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IN VIEW of the fact that my readers are familiar with the anatomy of the temporomandibular joint, I shall deal straight away with current opinions concerning the movements in the two joints and the correlated motions of the lower jaw.

BASIC MOVEMENTS

There are two different kinds of articular movement owing to the division of the joint into upper and lower articular chambers. In the upper half of the joint, movements occur in the form of gliding in various directions, whereby the condyle with the meniscus shifts on the eminentia articularis. The term acceleration has been used to define this gliding movement. In the lower half of the same joint, a rotation takes place involving the condylar head. Nor does this rotation as a rule work around a fixed mathematical axis, through the centers of the two condylar heads, because the condylar head transversely does not have a circular shape, being slightly irregular, and the longitudinal axes of the two condylar heads do not run along the same straight line (Fig. 1). However, the deviations as regards the movements concerned in this connection are so slight as to be negligible in practice. Generally a rotation is taken into account which is assumed to occur around an axis through the centers of the two condyles, being termed the condyle axis.

These gliding and rotating movements in the mandibular joints in their turn give rise to the *various movements of the lower jaw.*

Certain types which may be called *basic movements* are distinguished. They include the opening and closing movements, the forward gliding movements, and the extreme lateral movements. In addition, certain scientists lay stress on the occurrence of a retropulsive motion which cannot be regarded as being of the same significance. All the other movements performed by the lower jaw are combinations of these basic ones. They have been termed *intermediary movements.* The *opening movement* of the lower jaw and the closing movement will not be discussed because they are unnecessary to this discussion. Only the manner in which these movements of the lower jaw affect the construction of an articulator will be discussed.

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THE FIRST MOVEMENT AND OPENING AXIS

About fifteen years ago, a Swiss scientist, Fischer,[2] devoted particular attention to the question of where the opening axis of the jaw is situated. He found that the lower jaw can perform two different opening movements. During the *physiologic opening movement,* which represents the movement considered earlier in Europe as the only one, a gliding takes place in the upper part of the joint simultaneously with a rotation in the lower part. The lower jaw turns round an axis which is variable during different phases of the movement. Presupposing an average inclination of the condyle path, Gysi[3, 4] observed that this axis, during the first few centimeters of the opening movement is situated approximately 1.5 cm. downward and backward in relation to the condyle axis. However, Fischer carried out certain experiments in order to discover whether the lower jaw always

Fig. 1.—Mandible with the condyles seen from above. Note the dotted lines showing the direction of the longitudinal axes of the condyles (Swenson).

followed this path in its opening movement, that is, whether that path is identical with the one traced by the lower jaw during its passage through centric occlusion positions at different vertical dimensions. He began by registering the centric occlusion in an edentulous case, using occlusion rims adapted to the lowest possible vertical dimension. By means of a face-bow registration, he mounted the upper cast in an articulator where the opening axis coincided with the condylar shaft. Then the lower cast was mounted in the occlusion obtained. The vertical dimension was increased in the articulator, and the new centric occlusion obtained was tested in the mouth of the patient. He observed that he was able to increase the vertical dimension up to about 3 cm., the centric occlusion in the articulator and in the mouth still coinciding. When he tried the same experiment in a case with natural teeth, the centric occlusion coincided until the vertical dimension was increased about 2 cm. This, according to Fischer, proves that the opening movement of the lower jaw, when the vertical dimension is changed in the way

described here, takes place merely by rotation around the condyle axis, thus following another path than that of the physiologic opening movement. He called the newly discovered movement the *central opening movement,* as distinguished from the physiologic one. Fischer's conclusions derive support from the Swedish dentist Beyron's combined graphic and roentgentomographic examinations which were published in 1942.[1]

On the basis of Fischer's experiments, the conclusion may be drawn that when the opening axis of an articulator coincides with the condylar shaft, and when a face-bow is used by mounting the upper cast, the centric relation will not be lost by manipulations with the usual check bites. When, for instance, the centric relation is registered with a wax check bite in a case with natural teeth, it is always obtained at a slightly increased height.

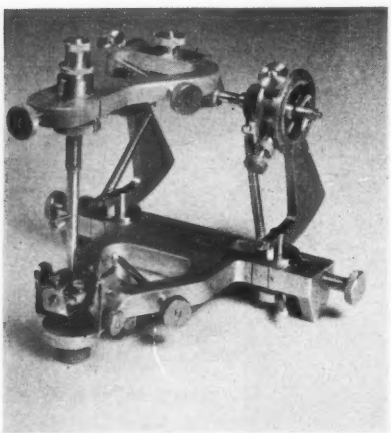


Fig. 2.—The author's instrument.

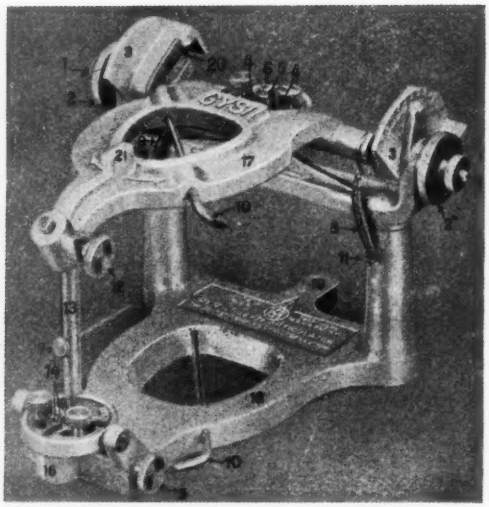


Fig. 3.—The Trubyte articulator.

Beyron's examinations, however, showed that the rotation axis does not invariably coincide with the assumed condyle axis. In order to insure accuracy, the true position of the axis will have to be registered.

For this purpose, Hanau[7] earlier constructed a kinematic face-bow. McCollum[8] appreciated these difficulties and built another instrument for determining the real rotation axis.

In short, the predominant conception is that a rotation axis exists, and the opening axis of modern articulators coincides always with the condylar shaft. This also applies to my own apparatus (Fig. 2). In some of the earlier European articulators, particularly those constructed by Gysi, the opening axis does not coincide with the condylar shaft but corresponds to the axis of the above-mentioned physiologic opening movement in cases with average inclination of the condyle path.

In a later instrument constructed by Gysi (the Trubyte articulator) the opening axis has been made to coincide with the condylar shaft (Fig. 3). However, he emphatically maintains that manipulations with check bites in the way mentioned here cannot be performed in the articulator.

When discussing the mechanical details of my own articulator, I shall be comparing it with the Hanau articulator, Model H (Fig. 4), and the Gysi Trubyte instrument.

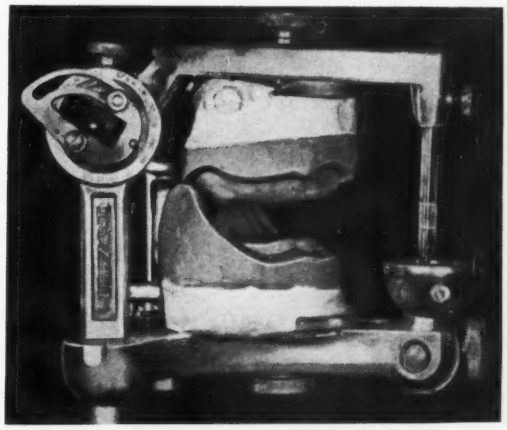


Fig. 4.—The Hanau articulator.

THE SECOND MOVEMENT

The second basic movement is the *forward gliding movement.* As will of course be easily conceived, an acceleration will invariably occur during this movement, as well as in certain instances a minor rotation.

Four examples may be given as follows:

1. When the cusps in a well-balanced case have but slight inclines and when no vertical overlap is manifest, only an acceleration can be referred to during the forward glide. The teeth are then arranged so as to make the occlusal curve follow a circular arch. Further, this circular arch also must coincide with the condyle path or a circular arch, concentric to the former arch, must coincide with the afore-mentioned path. The lower jaw will then move in the forward glide around an axis through the center of the circle or circles concerned. This axis is situated upward and forward in relation to the condyle axis (Fig. 5).

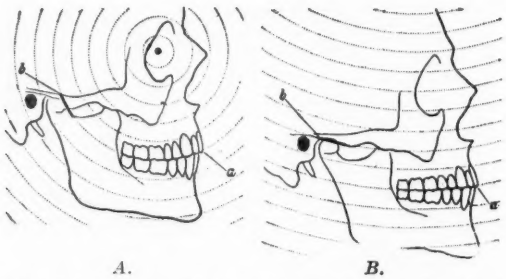
In the three other cases a vertical overlap is presumed to exist.

2. When the vertical overlap produces an inclination of the sagittal incisor path that is equal to the inclination of the condyle path, a protrusion will take place in the form merely of an acceleration. The whole process results in a purely parallel displacement of the lower jaw, which movement has been called a translation (Fig. 6).

3. When the inclination of the incisor path is less than that of the condyle path, the lower jaw turns in its entirety around an axis situated approximately in the same area as the first example, that is, forward and upward from the condyle axis (Fig. 7, *B*).

4. When, on the other hand, the incisor path is steeper than that of the condyle, an acceleration will likewise occur, and the lower jaw will turn around an axis situated downward and backward in relation to the condyle axis (Fig. 7, *A*).

Certain articulators have been specially constructed with regard to an axis for a protrusive movement, among them the Monson articulator (Fig. 8) and the Hagman balancer in particular.



A. *B.*

Fig. 5.—*A*, The overjet (*a*) (no overbite); *b*, the condyle path coinciding with the circular arch of the occlusal curve (Hall). *B*, The condyle path coinciding with a circular arch concentric to the occlusal curve (Hall).

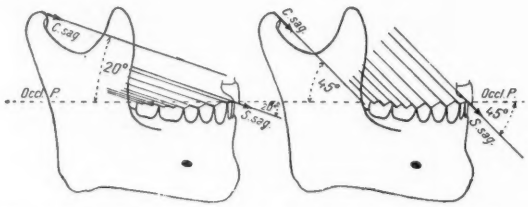
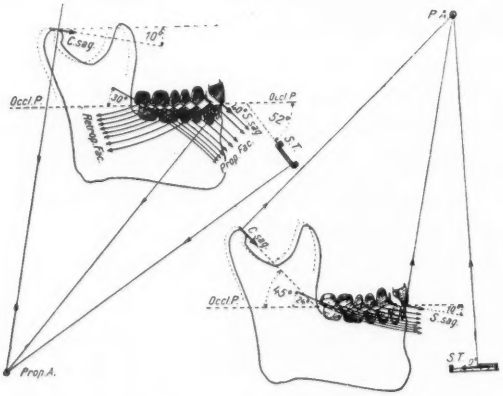


Fig. 6.—Parallel displacement during forward movement of the mandible when the incisal angle and the angle of the condyle path coincide (Gysi).



A. *B.*

Fig. 7.—Position of the axis during forward movement varies with the incisal angle (Gysi).

In the Gysi Trubyte articulator, the Hanau articulator, and the instrument constructed by me, no such axis has been applied, the variations in the pro-

trusive movement being reproduced by an individual adjustment of the condylar guide and by means of a device for reproducing the incisal guidance (Figs. 2 to 4).

The incisal guide can be adjusted at different inclinations in the sagittal plane, by means of which the movement of the incisal pin may, in the individual case, be made to coincide with the incisal guidance. The inclination of the incisal guide in the sagittal plane in my instrument can be registered similarly to the graduation into different inclinations of the condylar guide. The same applies to the Gysi Trubyte articulator, but not to the Hanau instrument.

Fig. 8.—The Monson articulator.

THE THIRD MOVEMENT

The third of the basic movements are the *lateral movements.* In order to obtain a more detailed conception of the movement or movements (considering that they occur on two sides), I shall begin by describing Gysi's original apparatus for recording them in cases of full denture prosthesis, since he was probably the first to register the lateral movements in this manner. In the median line of the upper occlusion rim, Gysi fixed a registering point which could move on a small table applied to the anterior part of the lower occlusion rim. A layer of black, soft carding wax or soot covered the surface of this registering table. The occlusion rims were placed in the patient's mouth and he was made to perform gliding movements of the jaw in all possible directions. (Figs. 9 to 11.)

It was then found that the stylus traced a figure in the wax or soot layer of the table, resembling a rhomb (Fig. 12). When the pin is at the anterior point of this rhomb, the lower jaw is in its *central occlusion position,* that is, the condyles are at rest in their most retrusive position in the fossa mandibularis from where lateral movements can be made. When the stylus follows one of the anterior sides of the rhomb, a lateral movement is performed which is called the extreme lateral movement toward this side. The angle formed by the anterior

sides of the rhomb has been named the Gothic arch. This arch can be considered as a tracing of the extreme lateral movements of the point where the incisal edges of the central incisors of the lower jaw meet. This point has been referred to as the median incisal point, or symphysis point. The movement track has been

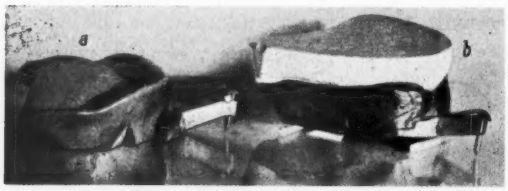


Fig. 9.—Gysi's registering point in the median line of the upper occlusion rim.

Fig. 10.—Gysi's registering table attached to the lower occlusion rim.

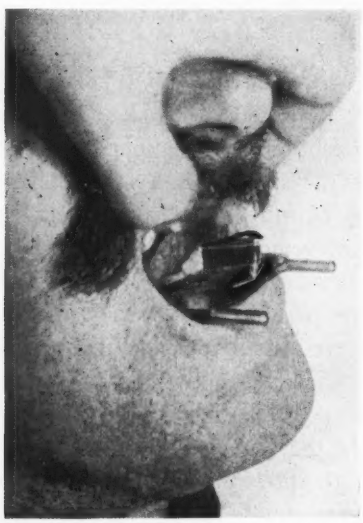


Fig. 11.—Occlusion rims with Gysi's apparatus in the patient's mouth.

called the symphysis path. However, it should be emphasized that the design thus obtained represents the symphysis path in the case of the movement of flat rims against each other, that is, without the influence of cusps. When the teeth

have been mounted, a slight opening movement is added to the lateral motion, caused by the height of the cusps. The Gothic arch will then be another, somewhat wider, angle figure. Stansbery[11] was the first to pay attention to this fact. When the casts have been mounted by means of the face-bow in my articulator, this variation of the Gothic arch can be obtained directly (Figs. 13 and 14).

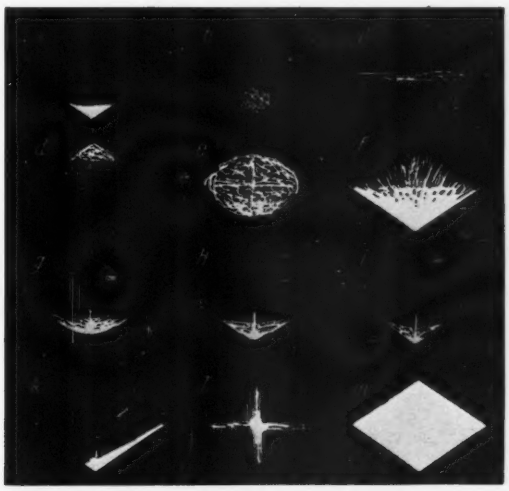


Fig. 12.—Various drawings made by the stylus. Perfect drawings are *f*, *i*, and *m*. In all other cases the patients are suffering from temporomandibular joint arthrosis to a certain extent, the movements in the joints being impeded (Gysi).

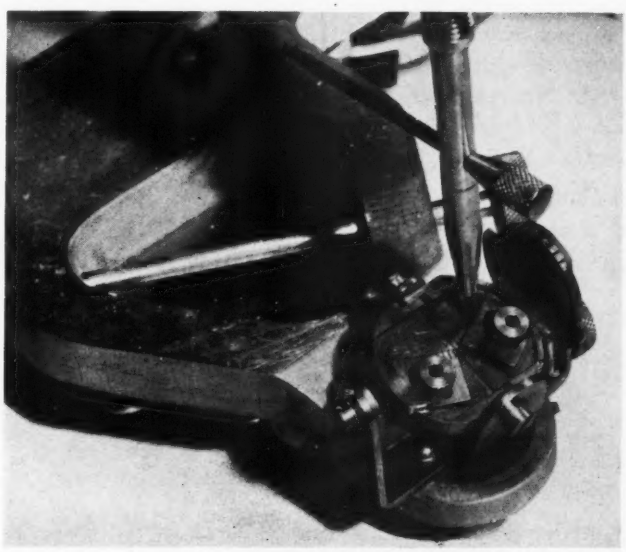


Fig. 13.—The incisal pin is in a lateral position resting behind the small plate on the incisal guide table. The two halves of the table are fixed in the horizontal plane corresponding to plane bite rims. The small plates are fixed in positions reproducing the individual Gothic arch registered in a case.

In the Gysi Trubyte articulator this can be done, though less conveniently. In the Hanau articulator, which is not supplied with a means of reproducing the

Gothic arch (Fig. 15), this is impossible. When studying a Trubyte articulator, or my instrument, a special device will be noted in the form of small plates applied to the incisal guide, rendering possible adjustment of the movements of the incisal pin in accordance with an individually measured Gothic arch.

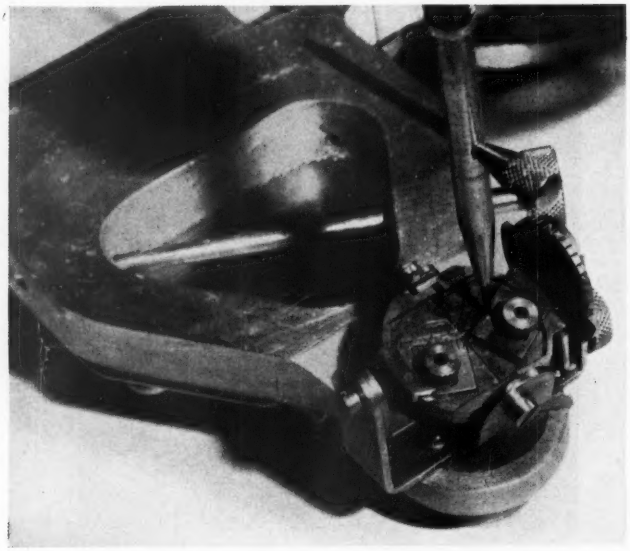


Fig. 14.—The two halves of the incisal guide table are now raised corresponding to the cusp inclines of the first molars, that is, about 10 degrees on each side in relation to the horizontal plane. Now the incisal pin will not follow the margins of the plates. These must be arranged to a wider Gothic arch angle. When they are moved to positions so that the incisal pin follows their margins again, you will get the real Gothic arch for setting up the teeth.

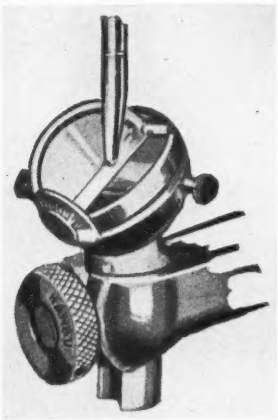


Fig. 15.—Universal incisal guide attached to the Hanau articulator (Hanau).

I have now briefly described the incisor path during lateral movements. This so-called Gothic arch is not always the same, but shows variations with regard to the size of the angle. In relation to a line in the sagittal plane, the angle may even be different on either side.

RELATIONSHIP BETWEEN GOTHIC ARCH AND JOINT MOVEMENT

I will now describe the variations of the Gothic arch in different cases and then discuss the movements in the two joints that give rise to this Gothic arch.

The different *functional positions,* as they have been termed in the title of this paper, arise from the various basic movements performed by the mandible. Apart from the central occlusion position, we notice a protrusive position and a right and left lateral position. When the lower jaw is in a lateral position, the side to which it has deviated is called the working side. The opposite side is the balancing side. The balancing condyle always passes forward and downward on the tuberculum articulare, and at the same time inward. The working condyle may in certain instances be assumed to remain in its resting position, only a torsion taking place in this case. It then forms the torsion center of the whole mandible. However, as a rule this condyle also moves, though to a much smaller extent than the balancing condyle. In the majority of cases it shifts in a direction forward and sideward, the lateral movement predominating. It is considered capable sometimes of going backward and sideward, and even straight backward, and backward and inward. These variations in the direction of the movements of the two condyles cause the varying appearance of the Gothic arch. The more protrusive the condyle path of the working side, the sharper is the angle formed by the arm of the Gothic arch directed to the same side with a line in the median plane. According to Gysi, the size of the angle of the total Gothic arch generally varies between 100 and 140 degrees, but values of 90 degrees up to 170 degrees have also been registered. The inward movement of the balancing condyle and the outward movement of the working condyle cause the whole of the lower jaw to be displaced to the side of the lateral movement. This movement is generally referred to as the Bennett movement, after the English scientist who gave a description of it at the beginning of this century. It was, however, known long before then. This inward movement of the condyle of the balancing side varies, according to known investigations, from a few degrees up to 30 degrees and more, from the sagittal plane. Hanau maintained that the angle stands in a certain relation to the inclination of the condyle path in the sagittal plane, according to the following formula:

$$B = \frac{H}{8} + 12$$

where H is the value of the sagittal inclination of the condyle path and B is the angle of lateral displacement during Bennett movement. It is regrettable that no analysis in favor of this formula has been presented, as far as I am aware, in the dental literature. Evidence in support of this formula would have been desirable. However, it has, as a rule, been accepted and I only know of one scientist in the literature, Gysi, who has offered criticism, classifying it as basically wrong. In order to fix the individual actual value of this angle, it can best be found, according to Gysi, by a geometric construction. I shall not dwell upon the complicated mode of procedure. Those interested will find an excellent description in a work by Gysi and Köhler published in 1929.[5] Gysi, however, states that this is one

of the movements of the lower jaw where an average value can be applied even when a high degree of accuracy is wanted. (Figs. 16 and 17.)

Gysi fixes this average at 15 degrees. My own instrument is adjustable at this movement from 0 to 30 degrees but, in practice, I always use the 15 degree position. The Gysi Trubyte articulator and the Hanau instrument are adjustable from 0 to 20 degrees. The mechanism for reproducing the movements of the condyles is similar in the Hanau instrument and in mine; that of the Gysi Trubyte articulator conforming, in principle, with them. Retrusion of the condyle of

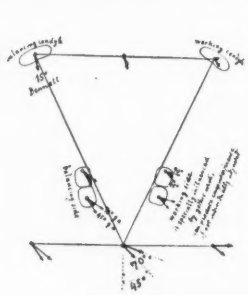


Fig. 16.

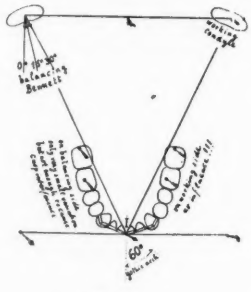


Fig. 17.

Fig. 16.—Extremes of different patients' lateral movements (shown by black triangles on the molars) when the halves of their Gothic arches are either 45 or 70 degrees in combination with an average Bennett angle of 15 degrees. This shows the importance of registering any patient's individual Gothic arch.

Fig. 17.—The drawing shows that if the Bennett angle is varied from 0 to 30 degrees, the Gothic arch being constant, there will be only small variations in the movements of a point on a molar of the balancing side, and no variations at all on the working side. Therefore, Gysi fixes the Bennett angle at 15 degrees (an average).

Fig. 18.

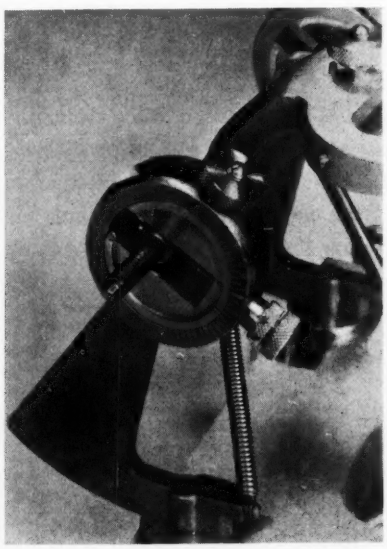


Fig. 19.

Fig. 18.—The Wadsworth articulator.

Fig. 19.—The condyle elements. When the thick screw is in the bottom, the condylar ball will be in its central position. When the thinner screw, which perforates the former, is screwed into the bottom the condylar ball is forced backwards corresponding to a protrusive movement of the human condyle.

the working side can be performed in the Gysi instrument and in mine, but not in the Hanau articulator. This movement is, however, less distinctly reproduced in the Gysi apparatus than in mine. The mechanism in my articulator for the reproduction of a retrusive movement of the condyle is not a new one, deriving from an American articulator, not mentioned earlier in this paper, the Wadsworth instrument (Figs. 18 and 19).

I shall now briefly refer to another movement which was mentioned in the beginning of this paper, namely, the so-called retropulsive movement. Gysi, in particular, urges the significance of grinding the teeth in a full denture prosthesis in order to harmonize with a movement where the lower jaw is slightly shifted backward. This movement can be performed in the Trubyte articulator and, thanks to the Wadsworth condylar mechanism, in my instrument.

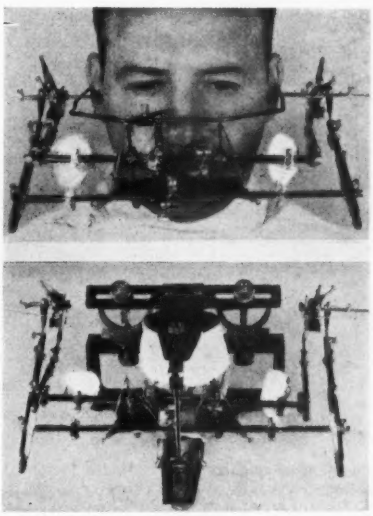


Fig. 20.—Registering apparatus according to McCollum (Simpson).

Broadly speaking, I have now accounted for the movements and functional positions of the lower jaw and the consequent construction details of my instrument. In this connection I will briefly describe the reproduction of the mandibular movements. An exact reproduction of the paths of movement in each individual case cannot be made by means of the instrument described here. I wish to draw particular attention to the fact that the condyle path is never straight but manifests quite a number of different curves. There is at least one articulator which is specially constructed to reproduce the individual movement path of the condyle. The instrument is constructed by McCollum.[8] Strictly speaking, the individual condyle path should, of course, be reproduced with minute correctness in our articulators, but in my opinion the registration of this path as well as the construction of the instruments would be too complicated for daily use (Fig. 20). The question is whether this would be worth while, except of course for scientific purposes. Considering that a lateral movement in the region of the first molar generally equals a maximum of 3 mm., it goes without saying that the devi-

ations from the straight path traced by these articulators cannot be of any particular practical significance. For this reason, no attention has been paid in my instrument to such individual variations of the condyle path. As regards the results of different movements, in other words, the functional positions, it may on the other hand be maintained that they are reproduced with great exactness.

Finally, only a few words need be said regarding other adjustment contrivances applied to my instrument. The two posts supporting the condylar mechanism can be placed at variable distances to each other, the instrument thereby being capable of adjustment according to the individual condyle distances. Experience has proved this to be of value in certain cases, the lateral movements in

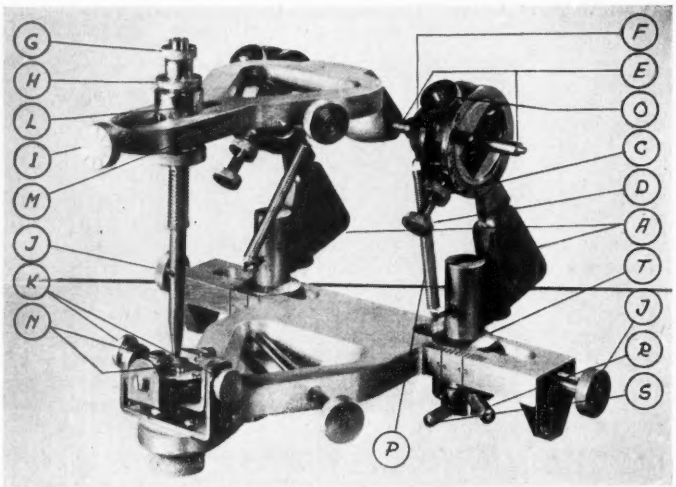


Fig. 21.—The latest model of the author's articulator with new elements for reproducing the individual Bennett angle. There are two locknuts (*R*) and (*S*) for adjusting each condylar post: one for rotation movements around the central vertical axis of the post, and one for locking the post when the intercondylar distance is to be adjusted. When a check bite in an extreme lateral position is placed between the teeth of the plaster casts or between the occlusion rims in full denture cases and the locknut (*S*) is released, the condylar post will turn from its position in the sagittal plane to another position and the Bennett angle is registered by the graduated baseplate (*T*).

the individual case being in this way reproduced more accurately. This adjustment of the variable condyle distances is also possible by means of the Wadsworth articulator which is, in this respect, the model for my own instrument. Furthermore, the incisal pin has been supplied with an adjustment mechanism which I believe to be unique. The pin can be raised or lowered by means of screw attachments as well as moved in a sagittal direction, the extent of these displacements being directly recorded in tenths of a millimeter. Such registration of the displacement can also be performed in the condylar mechanism, where the screws are graduated for measurement of the extent of the displacements up to tenths of a millimeter. Such graduations do not, as far as I am aware, occur in any other instrument. Thanks to these screws, the upper part of the articulator can be adjusted to different positions in relation to the lower part, corresponding to the

different functional positions of the lower jaw. In addition, these records permit the registration in mathematical values of the various positions. Therefore, should the check bites in a certain case have been destroyed or lost, the functional positions can nevertheless be reproduced, provided the record has been registered and the values noted down.

Summing up on the basis of previously mentioned facts I venture to maintain that the articulator constructed by me, without being particularly complicated in its practical construction, with regard to bite analysis, full denture construction, and partial restorations fulfills all the requirements which arise from our present knowledge of the movements and functional positions of the lower jaw.

My articulator now described has been used for investigations and in my daily practice since 1932. Some new modifications have been made so that I am able to register and reproduce directly in the instrument the individual Bennett angle, particularly in full denture cases. Experience has shown that the value of the Bennett angle obtained by using the Hanau formula is almost always incorrect. (Fig. 21.)

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THE NEWER DENTURE BASES WITH PARTICULAR REFERENCE TO COPOLYMER RESINS

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A LITTLE more than sixteen years have passed since I began working with acrylic resins. In that time they have displaced practically all other resins for denture bases. They had excellent properties, but there was the problem of how to get this resin into the mold, and the question, "What about its clinical behavior?" After some preliminary experiments, we were convinced that this type of resin had merit for denture use. Dr. Walter Wright was consulted and rendered valuable assistance in the clinical evaluation of this material which was new at this time. His conservative approach to the claims that should be made was a great help to this development. Without his unselfish and untiring efforts the advent of acrylic resin dentures might have been delayed for several years.

A discussion of the newer denture bases with particular reference to copolymer resins is a large order. The rapid progress in the field of copolymer resins has made it difficult, if not impossible, to keep completely informed on the subject. Even the patent examiners are three to five years behind.

DESIRABLE PROPERTIES OF A DENTURE BASE MATERIAL

It is necessary to list the desirable properties of a denture base material in order to evaluate the available resins as denture bases, and to determine how they might be improved. I will not attempt to list them in order of their importance.

1. *Ease of Molding and Processing.*—Molding and processing must be possible with simple equipment. There should be a minimum of inherent variables in the polymerization behavior.

2. *Ability to reproduce accurately* the details and dimensions of the pattern, and to hold that accuracy indefinitely.

3. *Permanent Freedom From Taste and Odor.*—The resin itself, when properly polymerized, should be tasteless and odorless. It should not absorb and retain tastes and odors of foods, beverages, or medicaments. It should not become fouled by absorption of water. Although water absorption should be as low as possible, molecular water can be imbibed without the denture's becoming foul. Certain types of material with a looser molecular lattice are rendered foul by the absorbed water and accompanying bacteria.

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4. *Chemical Stability.*—It should be a satisfied chemical compound which is not subject to oxidation. It should not undergo chemical breakdown or physical change in its molecular structure during its useful life as a denture. This latter requirement is related to possible toxicity.

5. *Freedom From Toxicity.*—It must be nontoxic, either in the monomeric or polymeric form. This rules out the use of some monomers which are quite toxic. For example, acrylonitrile monomer is reported to be about one-tenth as toxic as hydrogen cyanide. It must also be nonallergenic. Toxic compounds are frequently present in denture bases, as for instance, vermilion in rubber, or selenium in the pigments of resins. The selenium in the synthetic resins is so held by the body of the material that there is an infinitesimal amount of it on the surface, and the toxic effect is negligible.

6. *Strength.*—It must be strong enough to withstand the forces of mastication without breakage or permanent deformation. It must be resistant to abrasion during cleansing, and resistant to the moderate impact when the denture is dropped accidentally. It must be strong enough to retain metal inserts, such as bars and clasps, and to retain teeth.

7. *Heat Stability.*—It must be stable at temperatures exceeding any that can be borne by the mucosa or the hand. In general, the higher the initial softening point, the better. Most denture bases are permanently injured by temperatures near the boiling point of water.

8. *Physical Stability.*—It must be physically stable under mouth conditions. There should be no tendency to change due to gradual accommodation of processing strains, nor tendency to unmold under mouth conditions.

9. *Ease of Repair.*—It should be easily repaired, rebased, or relined by additions of the same material.

10. *Color Accuracy and Stability.*—It should be possible to incorporate color into the material so that it can be made to resemble oral tissue. The color should be permanent under service conditions and after repair.

The above list may be oversimplified, and it is possible that certain requirements have not been sufficiently stressed. In nearly every one of these requirements methyl methacrylate scores high; yet in almost any one of them there is some resin which will rate slightly higher. For instance, phenol-formaldehyde resin, either filled or unfilled, molded or cast, has a slightly greater hardness and scratch resistance than methyl methacrylate. On the other hand, it is very brittle in the unfilled cast state. Although in the cast state it has a very low water absorption, it has water troubles of another kind. Freshly made, it contains quite a measurable amount of water which is present as a result of its condensation. As the water is lost, there is considerable change in dimension.

The impact strength of the cellulose products is greatly superior to methyl methacrylate, but they score so low on so many other properties that their use has been almost discontinued. Vulcanized rubber scores low on its esthetic properties, and in taste and odor, and yet in many respects it is good, good enough that many

of the requirements in the American Dental Association Specification 12 were based on the properties of rubber. Vinyl chloride-vinyl acetate copolymers had some excellent properties, but dentures pressed from blanks of these resins failed because of breakage. Polystyrene in some of its newer modifications has interesting properties, but it cannot be molded with simple equipment. The list can be prolonged endlessly.

SYNTHETIC RESINS

All the synthetic resins now used in any quantity for dentures are members of the broad family known as the vinyl resins. Vinyl chloride, vinyl acetate, and vinylidene compounds have largely pre-empted the title, but acrylic resins, butadiene rubbers, and dozens of others are also in the family. They range in properties from polymers that are gummy and tacky to hard, infusible, and insoluable glassy materials. To enumerate all of them and their copolymers and modifications would comprise a list too long for this paper.

The language of resin chemistry has lagged behind technical development, and now and then we need to take refresher courses in nomenclature.

We have heard a lot about copolymers and interpolymers, especially in advertising and sales talks. The term copolymer is defined in a glossary[1] published in 1946 as: "Copolymer—Product formed by the simultaneous polymerization of two or more substances; it is not a mixture of separate polymers, but a complex having properties different from either polymer alone." The same glossary omits homopolymer and interpolymer.

In the authoritative textbook, *Vinyl and Related Polymers* by Calvin E. Schildknecht,[2] published in 1952, we find the terms homopolymer, copolymer, and interpolymer. Homopolymers might be described as single polymers. They can be formed even when two or more monomers are polymerized in the same vessel as in copolymerization, but they still polymerize separately. For example, monomers A and B may be mixed and subjected to polymerization. If neither of these monomers are reactive to the other, the A molecules would unite only with A molecules, and B molecules would unite only with B molecules. Since the two might be unreactive to each other and yet be in some measure compatible, the result surely would be a complex, having properties possessed by neither of the components alone. Copolymers might unite selectively with each other, and chains might form of units like A-B-A-B, B-A-B, or again as B-AAAB-BAAA-B; or cross-linking of A chains and B chains might occur. These interpolymers result when there is chemical homogeniety in the same sense as in homopolymers.

It is not our purpose to give a theoretical discussion of polymers but to suggest that those interested refer to standard organic chemistry textbooks for the basic reactions. We are primarily interested in the properties of these resins regardless of the theory of their formation or structure. So let us accept the 1946 definition of copolymers and simplify it to "polymerization of two or more monomers in the same kettle."

We can't mix monomers at random, put them in a reaction vessel, and expect to bring out something useful. It is somewhat like the reputed remark of

George Bernard Shaw, when a famous dancer suggested that a child inheriting his mind and her body would be a superman. He told her, "The risk is too great, It might inherit *my* body and *your* mind." Some monomers seem to be actual inhibitors for others. We cannot add up all the good properties of a host of monomers and get those good properties out of the product.

There is very little analogy between copolymers and metallic alloys, but that little analogy holds. If we add metals B or C to metals A, we do so because we have learned (perhaps empirically) that certain properties will be altered or extended thereby. The physical properties of hardness, toughness, machinability, et cetera, will be improved in some special way, or the cost of the material will be reduced, or its commercial supply extended.

If we wish to extend certain properties in a denture base material, we must decide which properties we can sacrifice to some extent, since it seems that we can't have perfection. We can add some polyfunctional monomer, such as allyl methacrylate, and introduce some cross-linking. That will improve the result by making the denture less soluble, but it will cut down its repairability. Water absorption, adaptation, and scratch resistance will not be improved in any measurable amount. We can add monomers which polymerize to softer polymers to increase the resiliency or toughness, but we sacrifice on the heat resistance, water absorption, and dimensional stability.

In addition, we must select a monomer which has a similar reaction rate, and a similar critical temperature to methyl methacrylate, if we expect to get a good homogeneous polymer as a result.

The earliest acrylic resins on the market were based on copolymers. Vernonite utilized a copolymer of methyl and ethyl methacrylates. Another early product was a copolymer of methyl methacrylate and an acrylate. Ethyl methacrylate is fairly close in its behavior to methyl methacrylate. The polymer is softer, more readily soluble, and has a much lower softening point. However, interpolymers can be made from these materials that have mechanical properties which all lie between the properties of the two polymers.

It is pretty safe to say that, excepting rubber and some recent developments in polystyrene, every denture base now being used has one of the methacrylates as a major constituent.

A brief scanning of the patent literature indicates that the acrylic resins play a large part, either as monomer or as a polymer, in most of the patents that have been issued in the last ten years involving denture bases. A patent issued to Homer van Bueren Joy,[3] Montclair, N. J., covers the use of vinylidene chloride-acrylonitrile copolymer, and methyl methacrylate monomer and polymer. Another issued to Frances E. Knock[4] of Oak Park, Ill., covers the use of methacrylate polymers and a monomer of di-chlorostyrene.

Efforts are being made to improve denture bases by additions to both the monomer and to the polymer. One manufacturer features additions of rubber, the type and amount are not specified. Data are lacking on these new developments, so I have nothing but opinions. Opinions are never good unless they are based upon facts.

AUTOPOLYMERS

There has been considerable interest in the so-called autopolymers recently. They first appeared as repair materials, and lately several have been marketed for denture construction. My own experiments with a resin of this type seem to indicate that they do not form complete polymers. In spite of the claims, I find that the activated monomers do not, even when heated, give a hardness as great as a heat-poylmerizing monomer will give with the same powder. Advertising claims that they are free of strain are not borne out when the dentures are heated to the softening point. There is about as much strain relaxation as in heat polymers. I can't say that dentures of these so-called autopolymers will change shape rapidly, but conditions prejudicial to postmolding change certainly exist. I use the term "autopolymer" since it is an accepted term in dentistry. Polymerization effected by the addition of a promoter (usually a reducer) and an oxygen-bearing catalyst, and completed without extraneous heat, is referred to as the redox reaction in chemical literature. It was developed largely by the rubber industry, both here and abroad.

The idea has some value for temporary dentures, such as field replacements of dentures in the military service, and I have no quarrel with it in minor repairs, but I doubt its usefulness to private dentistry in its present state.

NEW RESINS

There are new resins by the dozens coming out of the chemical research laboratories. The epoxy resins are an example. In these, two components, neither of which is in itself a resin, are mixed to form one. Some of these are literally without contraction. At present they are quite brittle when they are used without lamination. They come about as close to complete insolubility as a resin can, but they do not dissolve included air (a property which the methacrylates have), and they stick to everything. How to get them in a dental mold and out of it again is a real problem.

Some new phenolics are being made in pilot quantities. These also have almost no measurable contraction. They take several hours to polymerize, and they are prone to hold air bubbles. Unlike the epoxy resins they are tough, a little on the soft side, and about as insoluble as anything I have ever seen. We are continuing to experiment with them, but success is a long way off. One very big objection is their color, which is dark amber, but in time that might be overcome; that is, if we can get the air out, and get the foil off, and if we don't mind a long polymerization at temperatures higher than the boiling point of water.

Styrene polyesters of the "Selectron" type have been tried, and doubtless are in research now for use as denture bases. These esters are deficient in one property which was not included in the list of desirable properties of a denture base. For experimental purposes it is well to add it here. They do not have *gel* strength. That means that while the polymer is forming, it is insoluble in the remaining monomer, and the gel at a formative stage is weak and brittle. Poly-

merization contraction occurs, and causes weaknesses and actual cracks in the finished article. These polyesters are also air inhibited, as are a great many other monomers. Methyl methacrylate is perhaps less air inhibited than most of the other monomers of the vinyl family.

Considerable interest was shown in the diallyl diglycerol carbonate (CR39) resins. Possibilities may lie in that direction yet, for there are literally millions of combinations possible in that group. However, the resins up to now are brittle, unworkable, infusible glasslike solids. Preliminary work was done on making a molding mixture from some of these resins, but the project was dropped because the processing of the mixture was too difficult to put it into competition with molding mixtures already available.

ESTHETIC PROPERTY

Another trend that is appearing is the increased concern with the esthetic property of a denture base. The work of Pound[5] and others has pointed out the need for a new view, and a better conception of esthetics. Dentistry has been chiefly interested in the function of the denture, and that is as it should be. Because of the poor esthetic possibilities of vulcanized rubber, the patient could best be served by perfecting function. New teeth were developed both in porcelain and in resins, but the resin denture bases have continued to appear in candy pinks and cantaloupe shades. Some have fibers of nylon added in varying shades of reds and blues, but most manufacturers are content to produce and supply structureless delicate pinks that look nice in the hand, but look like nothing human in the mouth. With the resins that are essentially colorless in themselves, the colorability is limitless. The manufacturer should study color. That may be a good way for him to become more confused than he is now, but it is necessary if he wants to survive. He must study the physics of color and the psychophysics of color, because color is for the most part an illusion. He must borrow from the impressionist and the camoufleur; he must take facial make-up into account, for it is with us to stay; and he must go to nature for his inspiration.

I know nothing about dentistry, except what dentists tell me, but I believe that cooperation between the materials manufacturer, the tooth manufacturer, and the prosthodontist can still improve the naturalness of the denture with no sacrifice to function.

As to future developments in resin formulas, one guess is as good as another. Organic chemistry is moving rapidly, and no one knows what is now in the not too distant future. A totally new material that will render the acrylic resins obsolete by a general improvement in all of the necessary requirements must still be relatively simple to process without elaborate equipment, and must have few inherent variables in the resin itself. The new dream resin will have to be really good to outclass the acrylic resins on that score.

The production of plastics of the vinyl family in the United States is over two billion pounds annually. Styrenes alone account for more than one billion

pounds and the methacrylates for only thirty million pounds. Yet methyl methacrylate was chosen for research at the Massachusetts Institute of Technology to improve the engineering knowledge of plastics, to standardize testing, and to provide engineering data for the Plastics Manufacturers Association. Its dependability was the reason for the choice even though it is a minor commercial plastic. Any new resin will have to be good to displace methyl methacrylate as a denture base material.

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SIMILARITY OF TECHNIQUE FOR FIXED AND REMOVABLE RESTORATIONS USING REVERSIBLE HYDROCOLLOID

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A STUDY of the numerous articles and techniques on reversible hydrocolloid for restorative dentistry leaves no doubt as to the accuracy of the material. All of the authors, after extensive research, agreed that accurate and precision castings for restorative work can be produced from a good impression made with reversible hyrdocolloid.

In 1935 Sears made the statement that ". . . if a good accurate casting can be made for partial denture construction from an impression in reversible hydrocolloid, why not inlays and fixed bridges." The idea can be carried further. If an accurate partial denture can be constructed from an impression made with reversible hydrocolloid from a master cast duplicated for the casting, why not use a similar technique for fixed bridges. It is our opinion that more dentists will benefit from the accuracy of the reversible hydrocolloid, save hours at the chair, and construct better fixed restorations if the technique used parallels a procedure with which they are familiar, as in the making of removable partial dentures. Up to this time most of the techniques described for the use of reversible hydrocolloid in restorative dentistry have been somewhat complicated and time consuming for the average dentist, especially those who do not have use of the immediate facilities of a laboratory. This is one of the main reasons why the use of reversible hydrocolloid in restorative dentistry has not reached the popularity it deserves.

The main intent of this paper is to show the similarity in technique between fixed restorations and removable partial denture construction.

The advantages of this technique are:

1. The operator makes an impression and pours the cast just as he does to obtain any type of cast.

2. There is a minimum handling of impression, which is paramount in this type of work.

3. According to all research, accuracy is obtained by pouring the cast immediately after the impression is made. No time is wasted by this method.

4. If individual dies are poured, whether they are removed or separated by a metal matrix or held in position by parallel instruments, there is danger of distorting the impression. Besides, it is necessary to wait at least thirty minutes before the balance of the cast can be poured, which might produce an error in the cast. This cannot happen with the procedure to be described.

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5. If a die of the prepared teeth is poured, then removed after setting, and a complete cast is poured in the same impression, there is danger of tearing the margins. The surfaces of the prepared teeth on the cast are changed since the setting of the stone die which is poured first creates heat and draws moisture from the impression material and thus changes the conditions. Again, this cannot happen with the procedure to be described.

6. If two impressions are made, it is very difficult to maintain the same identical conditions in the mouth so as to produce two identical impressions, especially of the soft tissues. It is also time consuming and inconvenient to the patient. With our technique we have two identical casts. The second cast is a duplicate of the original cast after all the corrections are made. This is considered superior to two impressions.

7. Contact points are always accurate since there are no removable dies. Frequently when removable dies are used, there are discrepancies on the cast or dies due to usage. Also the presence of small debris might prevent proper seating.

8. If a fixed bridge fits the abutment teeth on the cast, it will also fit the abutment teeth in the mouth with a minimum of strain and subsequent irritation of the soft tissues and teeth themselves. This cannot always be said about removable dies because of reasons mentioned above in 7.

9. By this technique it is possible to construct any kind of fixed restoration or a combination of a fixed restoration with a removable partial denture or precision attachment.

10. A full cast is easily mounted on an articulator whether for a single or multiple restorations, thus obtaining more accurate occlusion.

11. This procedure is simple for both the operator and laboratory technician because it is very similar to the one already familiar to them, namely, that of partial denture construction.

DIAGNOSIS

It is agreed that an adequate diagnosis is the first step towards good dentistry. This is accomplished by (1) obtaining a case history, (2) digital and exploratory examination of the oral cavity, (3) full mouth roentgenograms, and (4) study casts properly mounted.

A few of the most essential requirements of a thorough diagnosis should be mentioned:

1. *Case history.*—The general health; any systemic disturbances such as diabetes or anemia that might affect the supporting structure of the teeth. The frequency of caries should be noted.

2. *Digital and exploratory examination* should determine the condition of soft tissues of the mouth, any abnormality (torus, etc.), periodontal involvement, presence of cavities in teeth, missing teeth, angulation of teeth, size of the crowns of the teeth, type of previous restorations, if any, and occlusion.

3. *Roentgenograms* should show the condition and type of the supporting bony structures, need for surgery (cysts, retained roots, granuloma, etc.), evidence of caries, length of the roots of the teeth, and condition of the existing restorations.

4. *Study casts* should show whether malocclusion is absent or present, tooth position in the arch and the relation to each other, tooth inclination and rotation, length of the tooth crowns, degree of undercut of the individual teeth, tissue undercut, need of surgery (tissue and bony undercuts), interridge space, degree of tooth wear, and tentative path of insertion for a partial denture if it is needed.

PROGNOSIS AND TREATMENT PLAN

On completion of the diagnosis, we can then determine the prognosis and plan of treatment.

It is now determined whether to use:

1. Inlays with one or more surfaces.
2. Three-quarter crowns.
3. Full crowns (jacket, all gold, or veneer).
4. Fixed bridges (different types).
5. Partial dentures (particularly if the abutment teeth need restoration).
6. Precision attachments.

It is emphasized that regardless of the restoration needed the same impression technique and the same laboratory procedure is to be followed.

CAVITY PREPARATIONS

The use of diamond stones is indispensable. No attempt will be made to prescribe the type of preparation for abutments or individual inlays. However, the preparations should be made more accessible for the introduction of the hydrocolloid.

The following cavity preparations may be used: Black's preparation, slice, modified slice, pin lays, slice lock, full crown, three-quarter crown, or any modified or combination of these.

EXPOSING THE CAVITY MARGINS

For convenience Pankey[8] classifies the gingival margin of the cavity preparation according to the position of the gingival margins.

Class 1.—The gingival margin of the cavity is not below the gum line (about 10 per cent of cases). The impression can be made without gum preparation.

Class 2.—The gingival margin is slightly under the gum line (about 75 per cent of cases). Pack the gum away from the margin with rope cotton, twine, or orthodontic rubber bands which are moistened with 8 per cent zinc chloride or 1/100 epinephrine or Sensitex (any good astringent). Allow it to remain in place two or three minutes and remove it just before making the impression.

Class 3.—A. The gingival margin is moderately deep under the gum tissue, but the gum is healthy and does not need to be removed. Pack the prepared cavity with Wondr-Pak and cotton or temporary stopping for twenty-four to forty-eight hours.

B. The gingival margin is deep under the gum tissue. The tissue is usually hypertrophied, bleeding, and becomes lacerated during the cavity preparation. Remove the gum tissue covering the margin by means of surgery or electric cautery. Pack with a surgical dressing and wait twenty-four to forty-eight hours.

REVERSIBLE HYDROCOLLOID

This impression material is composed of 6 to 12 per cent agar-agar as the active principle, about 70 to 80 per cent water, and the balance is made of various ingredients, such as rubber, wax, various salts, and other substances. Most of the reversible hydrocolloid materials on the market today are sufficiently accurate to produce an excellent impression. It usually comes in a metal or wax-covered commercial package. The material is also available in small 2 inch cartridges to fit the small syringes.

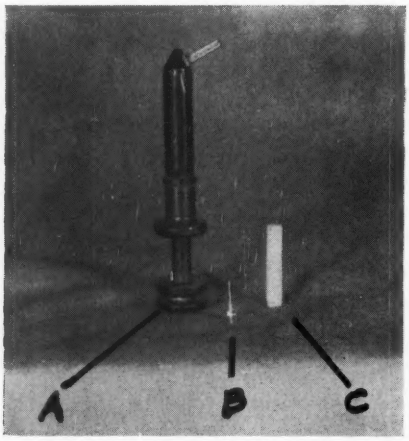

Fig. 1.—*A*, Hanau syringe; *B*, 20-gauge nozzle tip; *C*, cartridge of hydrocolloid.

Handling of Reversible Hydrocolloid.—

1. Hydrocolloid must be liquefied at a temperature of 206 to 212°F. from eight to ten minutes. This can be accomplished in an open vessel, sterilizer or one of the commercial conditioners.

2. In order to keep the material in a working condition and ready for use, it should be placed in a heater or heating compartment with a controlled temperature of 138 to 150°F.

3. When you are ready to make the impression, place hydrocolloid in the selected prepared tray and immerse it in a water bath of 115 to 118°F. for three to eight minutes, or long enough to permit the material to become evenly tempered. This will reduce the flow without permitting the material to solidify. It will also increase the body of the material.

Syringes.—There are several types of syringes available. If a Hanau conditioner is used, the Hanau syringe is recommended (Fig. 1). It is equipped with an air-release valve to eliminate trapped air and the outside cover is insulated so

as not to burn the patient or operator. Interchangeable nozzle tips (18-20-23 gauge) are supplied. The nozzles are used according to the size or type of the cavity preparation. The syringe is filled with the small hydrocolloid cartridge and placed in boiling water, 212°F., for eight to ten minutes. It is then kept in a conditioner ready for use at a temperature of 135 to 150°F. The material in this syringe is not tempered. In order for the hydrocolloid to flow through the narrow tip it has to be at least 135°F.

TRAY SELECTION

Whenever possible, regardless of the size of the restoration to be made, an impression of the full arch is advisable. This produces a more uniform impression, and the casts are easier to articulate. A solid water-jacket tray, without perforations, is preferred. It confines the impression material and a better impression is obtained.

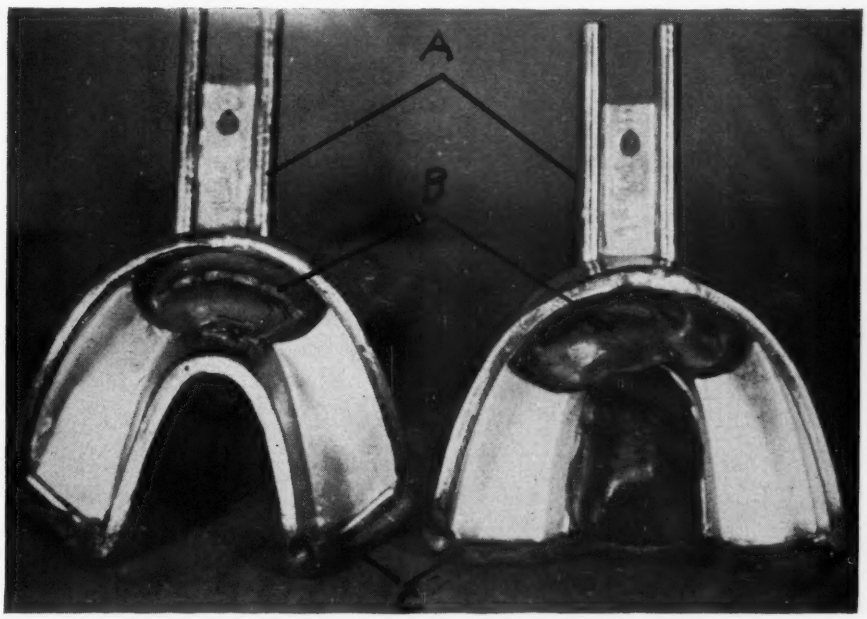

Fig. 2.—*A*, Water-jacket trays; *B*, compound stops; *C*, utility wax strip.

Use either a smaller, medium, or large tray, according to the size of the arch. Plastic compound or utility wax is used on the trays to act as a stopper, and also as a guide when carrying the tray to place. (Be sure that no compound or wax comes in contact with the prepared teeth.) A strip of utility wax is placed along the posterior border of tray to prevent material from flowing down towards the throat (Fig. 2).

THE IMPRESSION

1. The reversible hydrocolloid material should be prepared in advance as directed.

2. Remove the hydrocolloid from the 135 to 150°F. water bath and fill the tray. Start placing the material at the center of the tray and, with fingers wet with warm water, direct and smooth the material.

3. Completely immerse the filled tray in a tempering water bath of 115 to 118°F. for three to eight minutes.

4. Remove the packing from around the gum of the prepared teeth, clear the field by washing it with a water syringe, and then dry it with warm air. It is advisable to use cotton rolls and a saliva ejector to keep the mouth dry. Remove both just before inserting the tray with the impression material.

5. Take the small syringe from the storage compartment (138 to 150°F.) Lock the air valve and remove the metal cap covering the needle. Squeeze out a little hydrocolloid to assure its flow and wipe off the end of the needle. Start injecting the hydrocolloid into each prepared tooth from the gingival to eliminate any trapped air. Cover all of the tooth with the material. (At least all the margins of the preparation should be covered.)

6. Follow this immediately with the insertion of the filled tray that has been tempering in the water bath of 115 to 118°F. and to which the rubber tubing has been attached. (It is important that this step is done quickly, before the material that was released by the small syringe loses its flow).

7. Hold the tray in place firmly while it is cooling (four minutes if ice water is used, eight minutes for tap water). After the impression is completely chilled, remove it by a straight sharp pull to avoid tearing. The completed impression is washed under running tap water and immersed in a 2 per cent solution of potassium sulfate. The impression may be allowed to remain in the solution for a few minutes or longer if necessary. To obtain maximum accuracy the cast should be poured immediately after making the impression.

Impression of the Opposite Arch.—An impression of the opposing teeth is obtained. If restorations are to be made for this arch, the same technique is used to make the impression as described above; otherwise, a nonreversible hydrocolloid material may be used.

OCCLUSAL RECORDS

1. Occlusal prematurities, if present, should be corrected before the start of the cavity preparations.

2. If only one or two fixed restorations are to be constructed, the full casts are articulated in centric occlusion without the necessity of a wax bite.

3. If multiple fixed restorations or a combination of fixed and removable restorations are to be constructed, a face-bow transfer, centric and protrusive intermaxillary registrations are essential.

Shade of Teeth.—Determine the shade of the teeth to be used, fill the prepared teeth with a temporary filling material, and dismiss the patient.

LABORATORY PROCEDURE

1. *Pouring the Cast.*—Box the impression by first removing all the excess hydrocolloid, then seal Kerr's strip wax around the tray, and finally surround the impression with Kerr's boxing wax (Fig. 3). A thin mix of plaster of Paris is used to rinse the impression. Wash the plaster from the impression with running tap water. This procedure removes saliva, mucin, etc. Remove the surplus water with air.

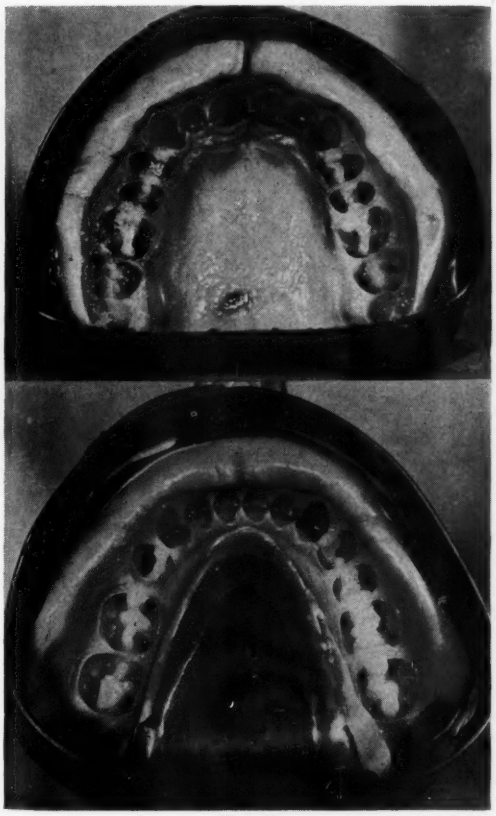

Fig. 3.

Fig. 4.

Fig. 3.—Completed impressions in reversible hydrocolloid, boxed ready for pouring of cast.

Fig. 4.—Original casts of the uppper and lower arch. (Note thirteen preparations in the posterior teeth.)

Mix hard stone for the cast. At present, we recommend Kerr's Vel-Mix stone. The mix is made in the proportions of 22 to 25 c.c. of water to 100 Gm. of powder by weight, or approximately one part of water to four parts of powder by volume. The powder should be added to the water and mixed by mechanical spatulation for one minute. The mix is poured with light vibration; a small portion of the stone is added at a time until the boxed impression is filled. (Notice that this cast is poured like any other type of cast used for partial denture construction. Individual dies are not made.) The poured impression is immediately placed in a humidor for at least forty-five minutes. Allow the stone to set sufficiently hard before separating the cast. The cast must not be allowed

to set in the impression over three hours because the exudate of the hydrocolloid may dissolve the water-soluble salts in the stone and produce a rough or etched surface (Fig. 4).

2. *Prepare Cast for Duplication.*—With a sharp instrument remove the globules which may be created by the air bubbles in the impression. Expose the cervical margins of the prepared teeth if necessary by scraping the cast with a very sharp instrument. Care must be taken not to touch the prepared teeth. It

Fig. 5.

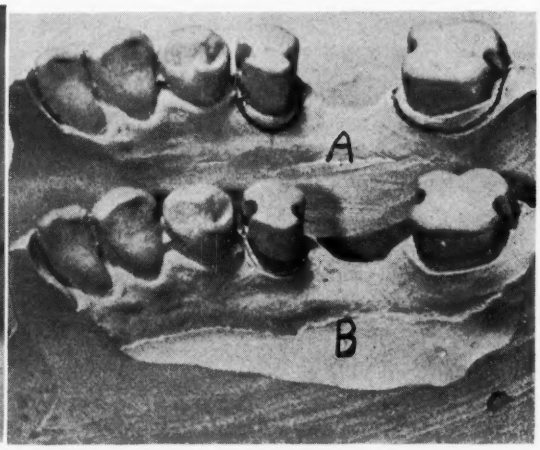

Fig. 6.

Fig. 5.—Labial view of veneer crown preparations. *A*, Original cast before scraping of cast. *B*, Same cast scraped around gingival before duplication.

Fig. 6.—Lingual view of three-quarter crown preparations. *A*, Original cast before scraping of cast area to be trimmed around gingival is indicated. *B*, Same cast scraped around gingival before duplication. Line indicates amount of area trimmed.

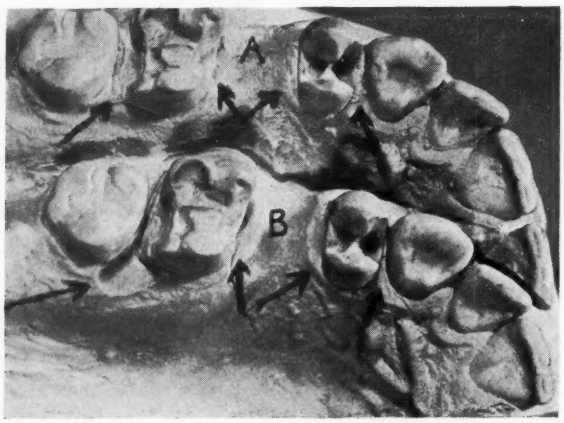

Fig. 7.—Occlusal view of mesiodistal-occlusal preparations. *A*, Original cast before scraping of cast. Arrows point to areas to be trimmed. *B*, Same cast scraped around gingival before duplication of cast. Arrows indicate areas trimmed.

is essential that these margins be well exposed and that the scraping be done at this time before the impression is made for the duplication of the original stone cast (Figs. 5, 6 and 7). When the duplication is made and a duplicate stone cast

is obtained, it will have identically the same exposure at the cervical margins as the original cast. This will eliminate any arbitrary trimming on the prepared teeth of the duplicated cast when the completed metal castings are to be fitted. If excessive undercuts are present around the base of the cast, they should be blocked out with wax or Moldine as is done when a cast is duplicated for a removable partial denture. Immerse the cast in a water bath at a temperature around 100°F. for a few minutes just before pouring the duplicating material.

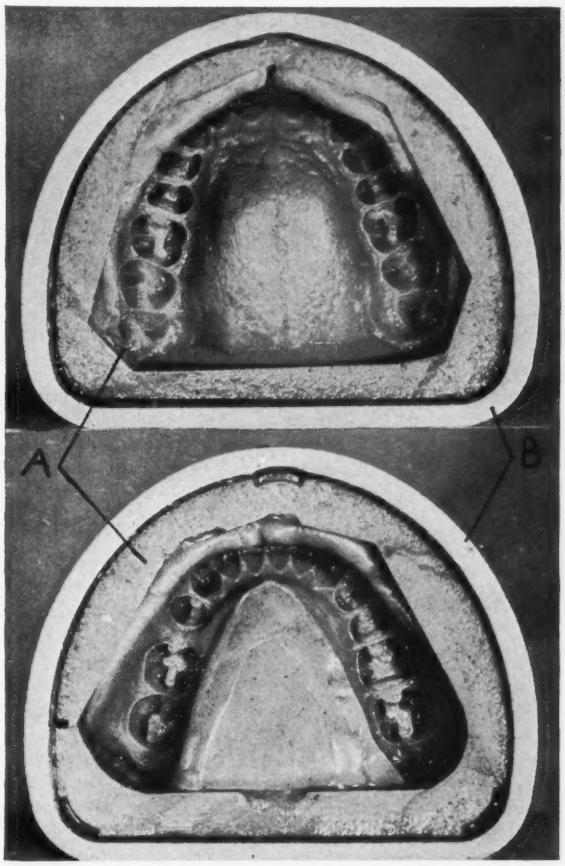

Fig. 8.—*A*, Upper and lower duplicate impressions. *B*, Duplicator.

3. *Handling of Hydrocolloid for Duplication.*—Dilute the hydrocolloid by adding a pint of water to two and one-half sticks of reversible hydrocolloid. Heat the hydrocolloid until it is reduced to a smooth consistency. The material is ready to pour at 140°F. At this temperature it will not affect the wax blocking out the undercuts. This hydrocolloid can be kept ready for use at all times at a temperature of 140 to 150°F. in a small Hanau conditioner.

4. *Pouring the Duplicated Cast.*—The cast is removed from the water bath and the duplicating flask is placed over it. The diluted hydrocolloid is poured into the duplicating flask until the flask is completely filled. Allow the material to set from three to five minutes. Then immerse the duplicating flask in water

and let it cool thoroughly before separating (Fig. 8). After separation, the stone is mixed and poured into the duplicated impression in exactly the same manner as the one poured in the original impression.

To maintain the accuracy and to facilitate the handling of the cast, split

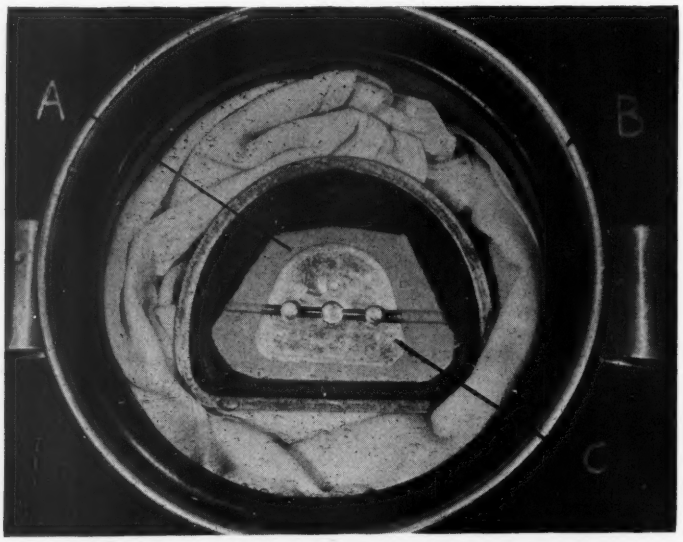

Fig. 9.—*A*, Cast poured in duplicated impression and placed in humidor *(B)*. Note split mounting ring *(C)* in position in the cast.

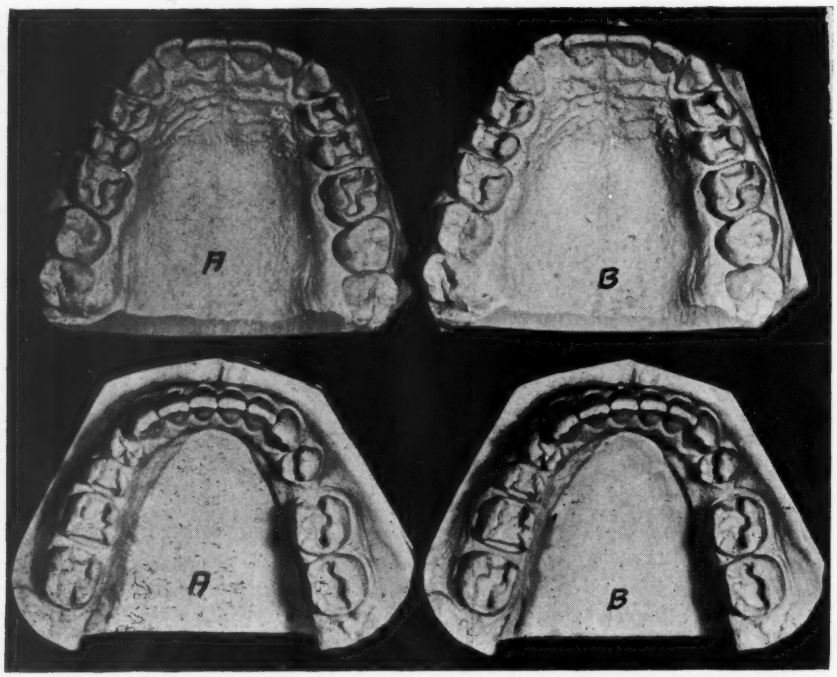

Fig. 10.—*A*, Original casts. *B*, Duplicated cast.

mounting plates are recommended (Fig. 9). They should be embedded in the cast at this time while the stone is still soft in the duplicator.

The poured cast is placed in a humidor for at least one hour and then separated from the duplicating flask. We now have two identical casts, one from the original impression and another one from the duplicate impression (Fig. 10).

Fig. 11.—Cutting dies from original cast.

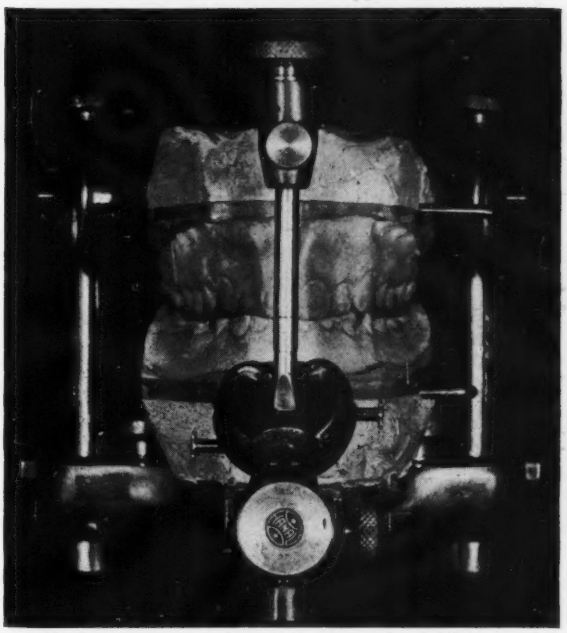

Fig. 12.—Duplicated upper and lower casts mounted on Hanau articulator.

5. *Cutting Dies.*—To eliminate as much error as possible the dies are cut from the original cast. The instruments used are a high-speed separating disk, width 0.025 and 1.5 inches in diameter, and an S. S. White metal cutting disk (Fig. 11). Once the dies are cut they are trimmed and the root portion tapered conically with a lathe abrasive wheel (Fig. 14).

6. *Articulation of Casts.*—The duplicate cast is articulated on an articulator of the operator's choice. Our preference is the Hanau articulator, especially if multiple restorations are to be constructed (Fig. 12).

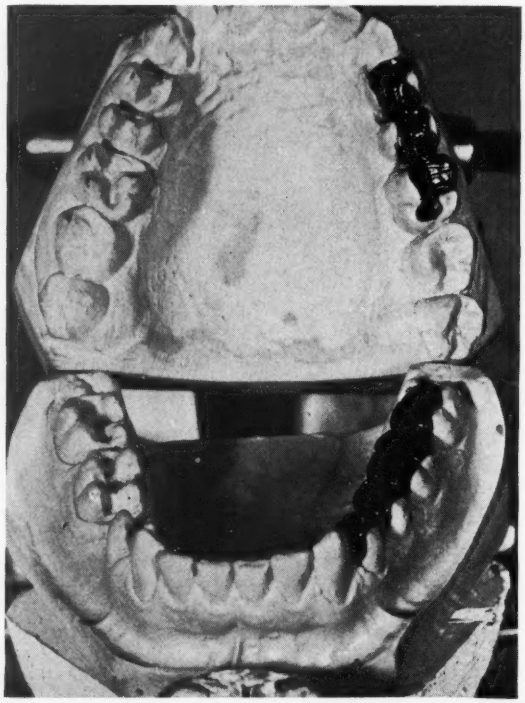

Fig. 13.—Wax patterns being formed on mounted upper and lower casts.

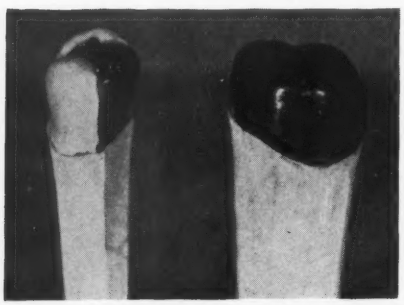

Fig. 14.

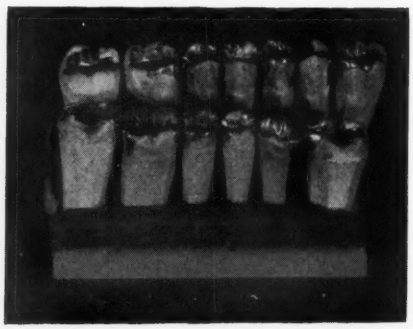

Fig. 15.

Fig. 14.—Final contouring of wax patterns on dies. (Note how the dies from original cast have been shaped.)

Fig. 15.—Casting in position on dies.

WAX PATTERNS

The dies and their replica on the mounted duplicated cast are lubricated with Kerr's Micro-film.

Soften Kerr's blue inlay wax and press into prepared teeth of duplicated cast. Close the articulator to obtain centric occlusion and contact points. Contour

the wax patterns in relation to the adjacent teeth (Fig. 13). Carve the occlusal surfaces to establish balanced occlusion. Remove the wax patterns and place them on the die. Finish contouring and burnishing the margins of the patterns on the die (Fig. 14). The wax patterns are now ready to invest.

At present we use an R & R Hygroscopic Investment and the technique as outlined by Scheu[11] and modified by Hollenback.[2] The castings are made with the Jelenko Thermotrol machine.

After the castings are completed they are placed on the dies to check the margins (Fig. 15). They are then placed on the mounted duplicated cast for selective grinding (Fig. 16). Adjust the restorations in centric and lateral occlusions. The castings are then polished and readied for cementation in the mouth.

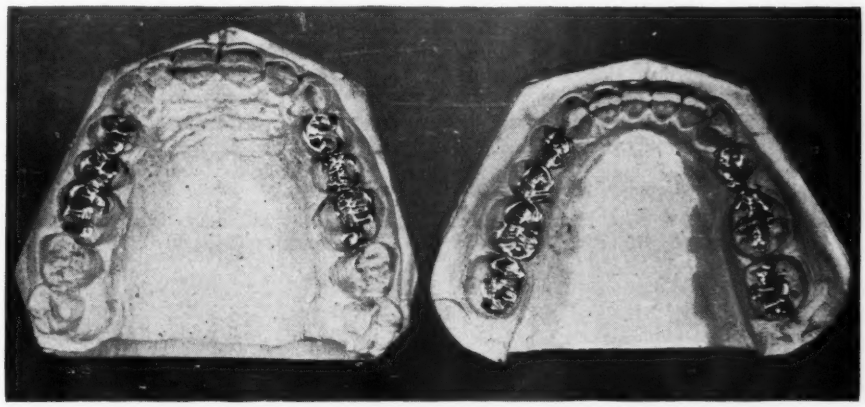

Fig. 16.—Castings in position on casts ready for cementation.

SUMMARY AND CONCLUSION

1. The technique described for making the impression in reversible hydrocolloid is similar to that described by other authors.
2. In the laboratory procedure, a full stone cast is poured immediately after making impression, and later this cast is duplicated.
3. Accuracy is increased because of the elimination of the use of removable dies.
4. The same procedure is used for all restorations, whether inlays, crowns, fixed bridges, combination of fixed restorations with removable partial dentures, precision attachments, or occlusal reconstruction.

The similarity of this technique to that used today for removable partial denture construction should facilitate its manipulation for the average dentist. With this in mind I hope that it will stimulate sufficient interest so that it will be applied in more dental practices. Carelessness has no place in the usage of reversible hydrocolloid. Attention to details in every step is of great importance in order to achieve maximum result.

The author wishes to acknowledge the origin of the laboratory procedure to my technician Mr. Glen Wakefield, without whose attention to details the description of this procedure would not have been possible.

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ATYPICAL PORCELAIN JACKET CROWN PREPARATIONS

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THERE are many phases to be considered in the construction of a porcelain jacket crown, such as impression making, instrumentation, fusing of porcelain, cementation, and so forth. However, the purpose of this paper is to direct undivided attention upon the most important phase, namely, proper tooth preparation.

The literature discloses that when techniques for a porcelain jacket crown preparation are described, the so-called normal or ideal tooth, usually the upper central incisor, is selected for such descriptions. While this is quite convenient for both the writer and reader of such articles, seldom do we have the good fortune to be presented with such an ideal situation. Such a preparation can be seen in Fig. 1, in which we have a preparation of normal length, width, and thickness, properly directed polished surfaces, and a uniformly placed and shaped shoulder. If we were continually dealing with this type of situation, such preparations would leave little to be desired; clinically, however, we know such is not the case.

In order to have the proper concept of jacket crown preparations, we must have this ideal foremost in our minds to serve as a standard to guide our operative procedures during instrumentation. Too frequently we overzealously attempt to apply or produce this ideal without giving attention to the existing conditions, and suddenly we find that the results fail to fulfill our utmost desires. Since our attention is not always on upper central incisors in ideal conditions, but on a variety of other teeth, and in a variety of conditions, it must follow that jacket preparations for all teeth cannot be the same. Attention to details, such as the anatomy of the tooth, the condition in which we find it, and its relative position in the arch are of utmost importance. If we observe these conditions carefully and modify our preparations slightly, the operative procedures that are associated with jacket crown preparation will prove to be less taxing on both the operator and patient, and will produce a more acceptable final result.

For many years, great emphasis has been placed upon the fact that jacket crowns should always have a well-defined complete shoulder. Some operators still adhere to this belief today; however, such is not the case. Many times a complete shoulder is contraindicated. A complete shoulder is always the preparation of choice, but when confronted with conditions such as carious areas, previous fillings, fractures, abnormal tooth development, and areas of great con-

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vexity or concavity, we must modify our preparations to meet these conditions. In the presence of these conditions, the development of a complete shoulder might produce harmful results such as pulp involvements, weakened tooth preparations, or periodontal disturbances. The two most important facts to keep in mind during porcelain jacket crown procedures are that the resulting crown be as uniform in thickness as possible and that it be adequately supported by tooth structure. Many operators have believed that they strengthened the resulting jacket by placing a complete shoulder around a preparation. Experimentation over the years has shown us that the shoulder has little to do with the inherent strength of the jacket. In reality strength is found in its uniform thickness and adequate support.

Since it now seems that complete shoulders are not always indicated, and in order that we may have a clearer conception of preparations for jacket crowns, let us classify the various types of so-called atypical preparations. Modification of preparations can be made on teeth with vital as well as nonvital pulps. Jacket crown preparations may be classified as (1) complete shoulder, (2) partial shoulder, and (3) shoulderless.

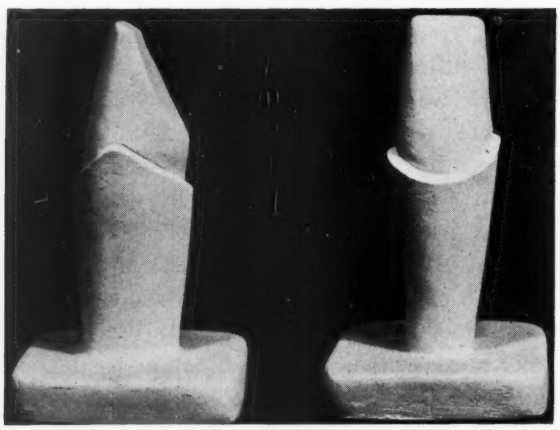


Fig. 1.—An ideal jacket crown preparation.

COMPLETE SHOULDER PREPARATION (VITAL)

This type preparation is always the one of choice, and every effort should be made to use it wherever possible. Teeth best suited for this type of preparation are the upper central incisors, upper and lower cuspids, upper second bicuspids, lower first and second bicuspids, and upper and lower first molars. These teeth have sufficient natural anatomy to accommodate the necessary tooth reduction without endangering pulp tissue, yet have sufficient tooth structure remaining to serve as a support for a jacket crown (Fig. 1). In this preparation, we have (1) normal length, (2) adequate width and thickness, (3) parallel proximal walls, (4) proper and sufficient incisal bevel, (5) complete uniform shoulder, (6) sufficient lingual reduction (approximately 1.5 mm.) for sufficient thickness of porcelain to withstand forces of stress, and (7) sufficient labial reduction for a proper esthetic result.

PARTIAL SHOULDER PREPARATION (VITAL)

This type of preparation is the one of second choice. However, to meet many clinical conditions as we find them, it is the best preparation indicated to meet the need. Teeth best suited for this type of preparation are the upper first bicuspids, upper lateral incisors, lower central and lateral incisors, lower cuspids with a marked concavity on the distal, thin teeth, underdeveloped teeth, bell-shaped bicuspids, and many other abnormal teeth.

SHOULDERLESS PREPARATION (VITAL)

This type of preparation is the least desirable of all jacket preparations. It is, however, the preferred preparation under certain clinical conditions. Shoulderless preparations are used as a conservative approach. If such an approach is not used, many teeth will be cut away unnecessarily, or excessively prepared, to a point where they would then fail to serve as a good foundation for the support of a jacket. Teeth which seem best suited for such a type preparation are peg-shaped lateral incisors, very thin lower incisors, badly decayed teeth, fractured teeth in the very young patient, bell-shaped teeth, teeth that have been improperly prepared, and teeth having exposed areas of cementum.

NONVITAL TEETH

The foremost indication for the placement of jacket crowns is for the restoration of vital teeth because the preparation for jacket crowns can be made without endangering the vitality of the teeth. Frequently we are called upon to place jacket crowns on nonvital teeth in order to meet an esthetic demand. If such a procedure is undertaken, we must give careful thought to the preparation, keeping in mind the brittleness developed by such teeth. We must endeavor to retain and properly use as much natural tooth structure as is available. Fortunately, we are not called upon frequently to construct jackets on nonvital teeth. If attention is given to a few details, excellent results can be obtained.

Nonvital teeth suitable for jacket crown preparation are those with (1) most of natural crown present, (2) part of natural crown present, and (3) all of natural crown missing or excessively weakened.

When most of the natural crown is present, the type of preparation indicated is entirely dependent upon the tooth. Such a preparation may have a full or partial shoulder, or it may be shoulderless. The point of importance is that such a tooth, because of its brittleness, must have additional support in order to be serviceable. This can be achieved by the insertion of a dowel or post of a suitable size into the root canal (Fig. 2). With such support, the possibility of fracture at some later time is minimized.

The post can be inserted at any time during the operative procedure, but experience has proved that its insertion and cementation is best accomplished at the start of the preparation. This reinforces the tooth structure to withstand the necessary cutting procedures.

Frequently, in the past, when there was a partial amount of the natural crown remaining, operators would cut away this sound tooth structure to the gingival tissue. Present-day practitioners believe that every effort should be made to preserve as much natural tooth structure as possible, consistent with the production of a good preparation.

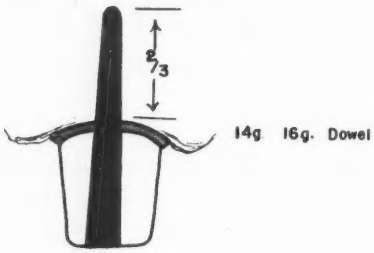


Fig. 2.

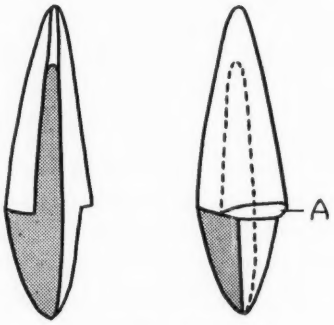


Fig. 3.

Fig. 2.—A dowel is inserted in nonvital tooth for additional support.

Fig. 3.—A partial shoulder preparation with a dowel and core to preserve weak tooth structure. *A*, Partial shoulder.

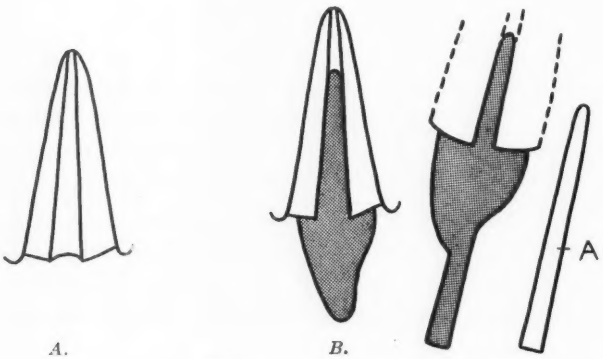


Fig. 4.

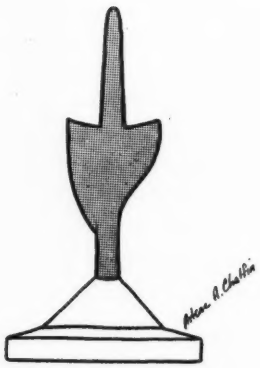


Fig. 5.

Fig. 4.—A cast core jacket crown preparation. *A*, Root preparation. *B*, Core (proximal).

Fig. 5.—Technique for construction of the cast core and dowel. *A*, Metal or acrylic dowel.

The root canal is prepared in the usual manner, free from all undercuts if possible. A gold core is constructed, either as one casting, or cast onto a dowel. This core is shaped so it does not possess any shoulder or collar. A shoulder is prepared into the remaining natural tooth structure slightly under the gingival (Fig. 3). The final preparation is completed after cementation of the core. Part of the preparation, usually the labial surface, will be in tooth structure, and the remaining sections will be in gold.

We are not always fortunate enough to have nonvital teeth in which dowels or partial cores can be used. Many times such teeth are so badly broken down or weakened that it is a sound procedure to reduce the tooth to the level of the gingiva and resort to a full gold core. When this procedure is decided upon, we must establish a full and accurate shoulder. If possible, we should reduce the

root surface until good healthy tooth structure is reached, and then prepare this surface as illustrated in Fig. 4. The method of construction is shown in Fig. 5.

Occasionally, carious areas will exist under the gingival margins. In these cases, small gold collars can be extended over these areas to support the weak tooth structure. The final preparation, shoulder formation, and polishing should be done after cementation of the core.

CORRECT SHADING (NONVITAL TEETH)

A difficult problem associated with all nonvital teeth is found in the production of the correct shade. Metal will impart a dark color to the resulting crown, and any effort made to change the result by the use of colored cements will prove unsatisfactory. One of the most satisfactory methods for handling this problem can be seen in Fig. 6. The labial surface of the core is cut out or prepared in a box-like manner for the reception of either acrylic or silicate filling material. These materials will prevent the gold color from showing through the crown and distorting its color.

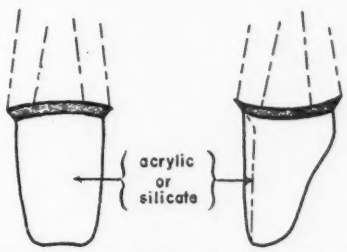


Fig. 6.—Gold core with trimmed-out labial surface for acrylic or silicate facing that will improve the esthetic result.

The two prime points to keep in mind during jacket crown preparation are (1) making the resulting crown as uniform in thickness as possible, and (2) be certain that the jacket has adequate support to resist displacing forces. These are the principal reasons for resorting to modifications of the ideal type of preparation. Should such modifications not be instituted, the resulting crowns will not be of equal thickness or they will not have adequate support. In many cases, if the operator insists on applying the principle of the full shoulder, he will endanger the vitality of the tooth.

Since modification of preparations have been established as an acceptable procedure, let us now take as many clinical applications as possible and discuss each in detail.

DIASTEMA

Occasionally a patient with a diastema is desirous of closing this abnormal space (Fig. 7). Great caution should be exercised in treating these patients for frequently they will expect results that are impossible to attain. Before beginning with the preparation, trim down or prepare the teeth on sectional or study casts to approximate the finished preparations. Mold white inlay wax around the prep-

arations, carving and contouring it so it resembles the finished crowns. This will enable you to show the patient approximately what it is possible for you to achieve. In the event the patient expresses satisfaction, proceed with the preparation as illustrated in Fig. 8. In this preparation, the mesial shoulder will be absent. This type of preparation is a conservative approach to the problem which will produce not only a strong but more esthetic crown due to its uniformity of thickness.

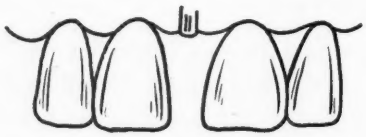


Fig. 7.—No mesial shoulder is used on the surface adjacent to a diastema.

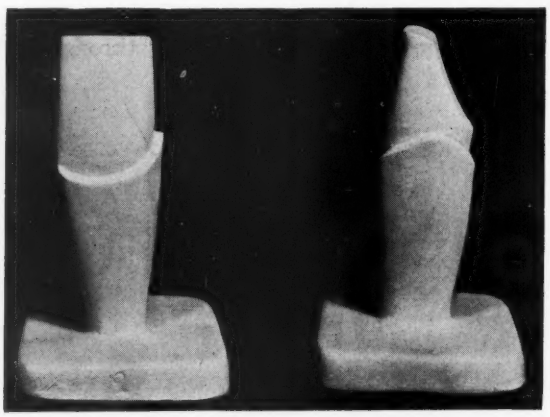


Fig. 8.—The mesial surface is prepared without a shoulder to permit a more uniform thickness of the crown.

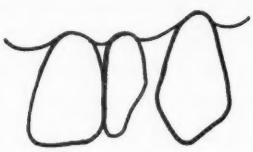


Fig. 9.—A mesial shoulder is indicated.

PEG-SHAPED LATERAL INCISORS

When the problem of restoring a peg-shaped lateral incisor, or some other underdeveloped tooth is encountered, a situation will exist frequently as shown in Fig. 9. There is a tight contact on one of the proximal surfaces and an excessive space on the other. If a full shoulder preparation is attempted on this tooth, the resulting preparation would be too narrow and subject to easy fracture. In order to produce a jacket which will be adequately supported and be esthetically acceptable, prepare the tooth as illustrated in Fig. 10. This preparation will be shoulderless on all surfaces except the mesial which will have a shoulder. By preparing the tooth in this manner, you are able to make a crown of uniform thickness in all areas.

MAXILLARY LATERAL INCISORS

The maxillary lateral incisors seem to be some of the so-called "problem teeth" for jacket crowns since the mesial and distal gingival contours are usually concave. These teeth are frequently crowded or slightly malposed, and if an effort is made to place a complete shoulder, the resulting preparation will resemble a tooth pick. The better approach to this problem is to place a shoulder

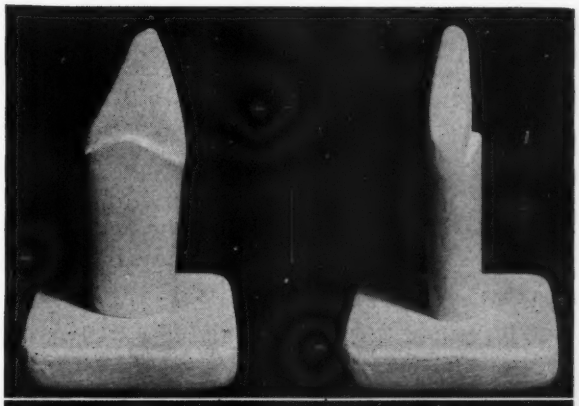


Fig. 10.

Fig. 11.

Fig. 10.—A preparation for a jacket crown for a peg-shaped lateral incisor.

Fig. 11.—A preparation for a jacket crown for a narrow lateral incisor. Shoulders are used only on the labial and lingual surfaces. The incisal groove adds strength.

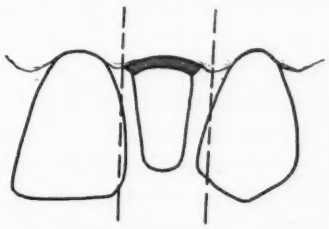


Fig. 12.—Modification of adjacent teeth is indicated when the space is reduced.

on the labial and lingual surfaces and to keep the mesial and distal surfaces shoulderless. This permits a wider and stronger type of preparation. When faced with the additional problem of having an edge-to-edge bite, we place an

incisal groove for additional strength. Such a preparation may be seen in Fig. 11. Frequently this tooth is crowded, and in order to secure a proper preparation slight changes of the adjacent teeth are permissible. The adjacent proximal surfaces are slightly trimmed and then polished (Fig. 12). This permits the use of a wider crown, and minimizes the cutting from the mesial and distal surfaces. The resulting crown will be adequately strong and esthetically correct because of its uniformity.

Fig. 13.

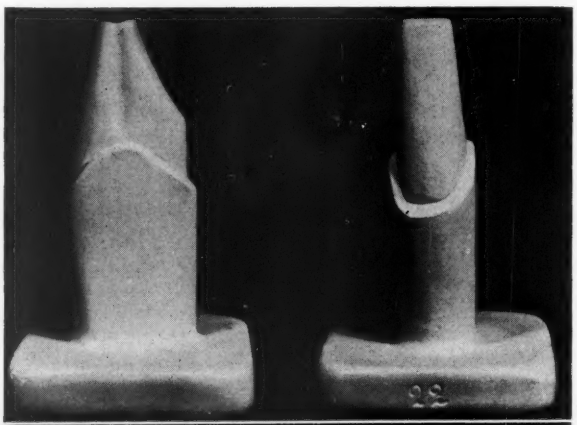


Fig. 14.

Fig. 13.—A preparation for a tooth in an edge-to-edge relation. Note the incisal and proximal grooves.

Fig. 14.—A preparation for a tooth with a large cervical filling.

Certain maxillary teeth must have modified preparations in order to meet clinical conditions such as their position in the arch, their condition, or the forces that are to be exerted upon them. An example is seen in Fig. 13 where the bite is edge to edge, and additional strength must be obtained by use of an incisal groove which permits a heavy rib of porcelain to be placed at the critical area, thus preventing fracture. Further strength may be secured by the use of axio-proximal grooves, which serve as aids against rotation of the crown and consequent fracture. Modifications of this type are particularly good on short thick incisors or on teeth that have abraded incisal edges.

PREVIOUSLY FILLED TEETH

Teeth with large cervical fillings present a problem. Usually these fillings are unsightly or defective and require restoration with jacket crowns. These fillings should be removed and replaced with the proper shade of cement. The tooth is prepared as in Fig. 14. A shoulder is formed on all surfaces except the labial which is kept shoulderless. Any attempt to create a labial shoulder will meet with failure, since the resulting shoulder would be either in cement or be carved so far gingivally as to produce unnecessary injury.

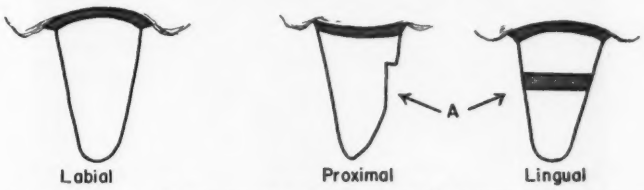


Fig. 15.—A preparation to correct a preparation with excessive convergence. *A*, Lingual groove.

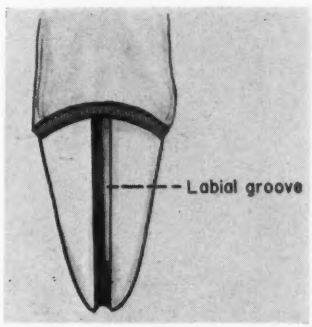


Fig. 16.—Excessive convergence (retention solely dependent on cement) corrected by a labial groove. Groove needed to prevent rotation and subsquent fracture.

EXCESSIVELY CONVERGENT PREPARATIONS

One of the most difficult problems encountered is the correction of a previously prepared tooth. The most frequent cause for jacket crown breakage is improper tooth preparation. If subsequent fracture is to be avoided, these preparations must be corrected. If the shoulder has been improperly cut, it must be re-cut, re-shaped, and polished. Frequently, the cause for breakage is an excessively convergent preparation. The reason for breakage is that such a preparation permits rotation of the jacket. This can be easily corrected by placing a lingual groove in the preparation. This serves as a stabilizer, and prevents the forces of rotation from exerting their full effect (Fig. 15). Additional problems are presented with previously prepared teeth on which we find an excessive convergent preparation and the lingual surface of the preparation restored with cement. A lingual groove in this cement will afford little additional strength against the forces of rotation. In these cases, we resort to a labial groove cut in sound tooth structure which serves to counteract the forces of rotation (Fig. 16).

Peg-shaped lateral incisors present a similar problem because of their natural convergence but they are more easily corrected since the existing natural tooth structure is present. This problem can be adequately treated by the use of a lingual groove (Fig. 17).

Fig. 17.

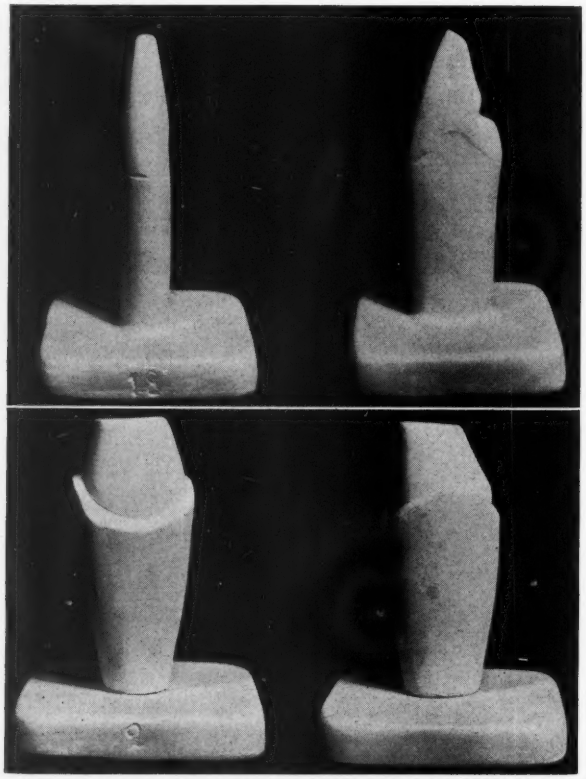


Fig. 18.

Fig. 17.—Lingual groove to correct excessive convergence of a peg-shaped lateral incisor.
Fig. 18.—An excessively short preparation.

SHORT MAXILLARY ANTERIOR PREPARATIONS

A common type of fracture seen in jacket crowns is the so-called "half-moon" fracture on the labial or lingual surfaces at the gingival margin. The cause for this type of fracture is usually that the preparation is too short (Fig. 18). If correction is to be attempted, additional length must be obtained for the preparation. This can be best accomplished by means of a gold coping built to the desired length. This will insure against further breakage (Fig. 19). Nonvital teeth that have been shortened, either by previous preparation or fracture, must be treated with extreme care. Since there is a need for additional support of the remaining tooth structure, and the preparation must have additional length, we resort to a partial gold core. This conservative approach produces a preparation that not only supports the remaining natural tooth but gives sufficient support to the resulting jacket crown. Every effort should be made to preserve as much of the natural tooth structure as possible in nonvital teeth. Final preparation of these teeth cannot be completed until after the partial core is cemented. At that time, final shaping, polishing, shoulder placement, or correction is made before proceeding with the subsequent steps in jacket construction (Fig. 20).

MANDIBULAR ANTERIOR TEETH

Mandibular anterior teeth may also be termed as problem teeth because of their natural anatomy. These teeth are quite small, fragile and triangular in shape, and hence they do not lend themselves to jacket preparation of the ideal type. If we attempt to place complete shoulders on these teeth, the resulting preparation would be too thin mesiodistally, and the prepared tooth would soon fracture.

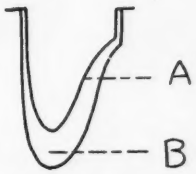


Fig. 19.

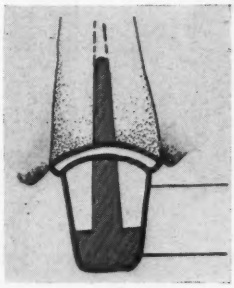


Fig. 20.

Fig. 19.—A gold coping to add length to the short preparation. *A*, Jacket preparation. *B*, Additional length obtained by means of gold coping.

Fig. 20.—*A*, Short preparation (nonvital natural tooth). *B*, Additional length obtained by means of a partial gold core.

Fig. 21.

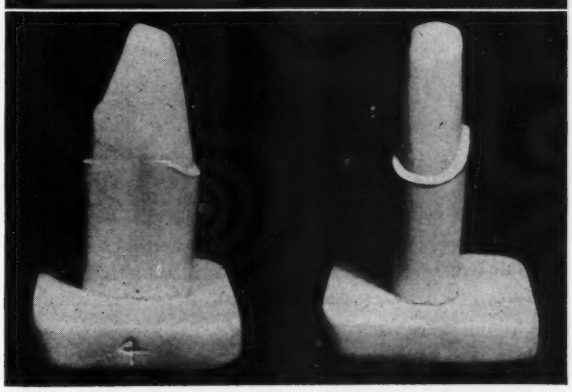


Fig. 22.

Fig. 21.—A preparation on a lower anterior tooth.

Fig. 22.—A preparation on a lower cuspid tooth.

The preparation of choice is one with labial and lingual shoulders, with the remainder of the preparation shoulderless. The direction of the incisal bevel is inclined toward the labial surface (Fig. 21). This bevel allows for greater bulk of porcelain at a critical area and prevents future fracture.

Fig. 23.

Fig. 24.

Fig. 25.

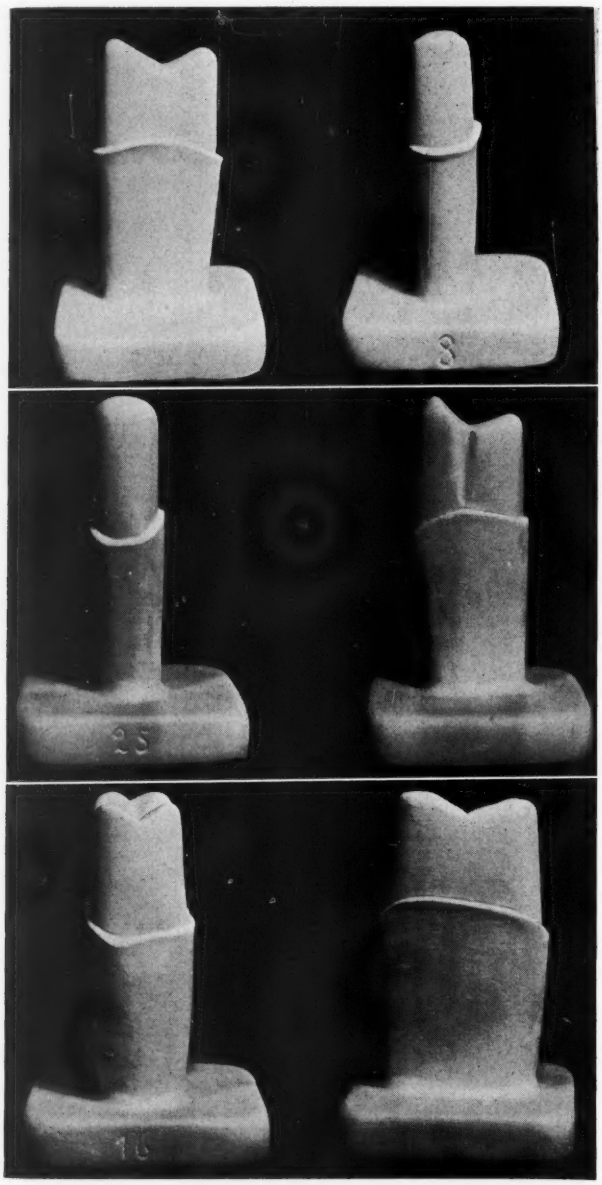


Fig. 23.—A preparation on an upper first bicuspid.
Fig. 24.—Axioproximal groove in a bicuspid preparation.
Fig. 25.—A preparation of a molar tooth in an ideal situation.

Lower cuspid teeth also present a problem at various times (Fig. 22). These teeth often have an excessively bulging distal surface with a resulting concavity

in the distogingival area because of their normal anatomy. If an attempt is made to form a uniformly complete shoulder on these teeth, excessive cutting would be necessary, and possible injury to the tooth might follow. The more conservative approach to this problem is to place a shoulder on all surfaces except the distal. Note also that the incisal bevel on this preparation is inclined toward the labial.

POSTERIOR PREPARATIONS

Most jacket crowns are placed in the anterior part of the mouth and, because of their accessibility and because occlusal forces are not too complex, we meet with little difficulty. However, in the preparation of bicuspid and molar teeth for jacket crowns, additional factors must be considered carefully and operative techniques properly executed if success is to be insured. Posterior jacket crowns are subjected to a greater variety of stresses than anterior jackets. The teeth must be prepared so as to resist these various stresses. Although jacket crowns for posterior teeth are ideal restorations, great care should be exercised in the selection of teeth for such a restoration.

The problems of preparations for posterior teeth are multiplied because of the position of the teeth and the amount of tooth structure to be removed. Generally, cuspal anatomy should be retained and all sharp line and point angles should be avoided. Since there is sufficient bulk of tooth structure, it is possible to place complete shoulders on most of these teeth. However, exception is found in the maxillary first bicuspid. This tooth presents a concavity in the mesiogingival area which must be considered during the preparation of the tooth. Any attempt to form a shoulder in this area will meet with failure, so the preparation of choice is of the shoulder type on all surfaces except the mesial (Fig. 23). Observe the maintenance of cuspal anatomy and rounding of all line and point angles.

Since bicuspids are subjected to additional stresses, axioproximal grooves are often recommended. They give added strength to the crown, and counteract the forces of rotation (Fig. 24). This type of modification is good if the tooth will be used later as an abutment.

With the multiplication of cusps, there is a multiplication of the number of stresses exerted on a jacket crown. This fact we must bear in mind in preparing molar teeth for jackets. If there is one part of a posterior preparation that might be considered the most important, it is in the preparation of the occlusal surface. This surface must give proper support to the jacket, or the crown will break.

If we have the good fortune to have a well-positioned molar tooth, and a cooperative patient who will permit the necessary operative procedures incident to the preparation, we should prepare the tooth as shown in Fig. 25. Such a preparation maintains cuspal anatomy and has a uniform well-placed shoulder, and rounded line and point angles. However, conditions are not always favorable. Frequently it is impossible to make this type of preparation, so a procedure as shown in Fig. 26 must be used. A rather heavy shoulderless preparation is made with a flat occlusal surface. A gold coping is constructed to produce the necessary cuspal anatomy, and the shoulder is placed at the proper position in the gold coping. Then the jacket crown is constructed.

Some of the reasons for failure in posterior jacket crowns are shown in Fig. 27. In order to protect the jacket further against breakage, the opposing occlusion must be corrected. This is done during tooth preparation, and not later. By re-shaping the opposing cusps, many of the lateral stresses exerted on the jacket crown will be eliminated. The wedging action of the opposing cusps which tend to push the cusps of the jacket crown apart will also be eliminated. The occlusal surface of the finished crown should be as narrow as possible, and all sharp or high cusps should be reduced or rounded.

The completed crown should have uniform thickness throughout, and the fused porcelain should be thoroughly condensed. If this is accomplished, and if the preparations are made properly, the patient may expect long service from jacket crown restorations.

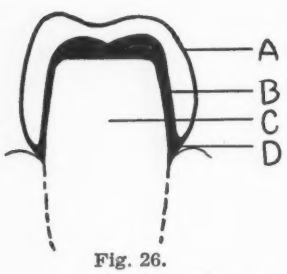


Fig. 26.

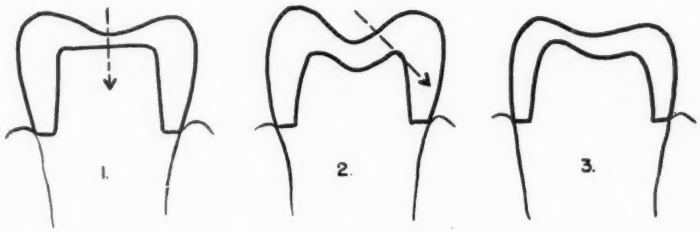


Fig. 27.

Fig. 26.—*A*, Jacket (molar). *B*, Gold coping. *C*, Preparation. D, Shoulder in gold. (After Brecker.)

Occlusal preparation is flat; cuspal anatomy is produced in gold coping. The cusps on the finished jacket must be well rounded. Occlusal carving on the finished jacket should be shallow.

Fig. 27.—Causes for failure of posterior jacket crowns.

1, Dotted line indicates area subject to fracture. Carved porcelain over the flat occlusal is poor.

2, Dotted line indicates area subject to fracture. Deep cusps will be jarred by opposing teeth.

3, Properly prepared tooth. Proper distribution of porcelain. Properly contoured and carved crown.

SUMMARY

1. The procedures that have been described are not hypothetical but have been proved clinically.

2. Jacket crown preparations cannot be the same for all teeth.

3. A complete uniform shoulder is not essential for all teeth although it is the preparation of choice.

4. The condition in which we find the tooth, its anatomy, and position in the arch are the factors that determine whether the preparation should have a full or partial shoulder or be shoulderless.

5. Preparations must be completed so that the resulting crown will be adequately supported and uniformly thick. This insures a durable, esthetically acceptable result.

Broad above Allegheny Ave.
Philadelphia 40, Pa.

AN ANTERIOR FIXED BRIDGE REPLACING A MISSING TOOTH WHERE ABNORMALLY LARGE INTERPROXIMAL SPACES EXIST

WALTER WYRICK, D.D.S.

Texarkana, Texas

A SIMPLE method of replacing a missing upper right central incisor with a fixed restoration where the anterior teeth have abnormally large interproximal spaces will be described in this case report.

A man, aged 38 years, presented himself for dental treatment. Clincal and radiographic examinations revealed a splendid tooth structure which was apparently immune to caries. However, there was extensive bone resorption involving the upper right central incisor. This was diagnosed as diffuse atrophy or periodontoclasia, and the tooth was removed. The upper right second bi-

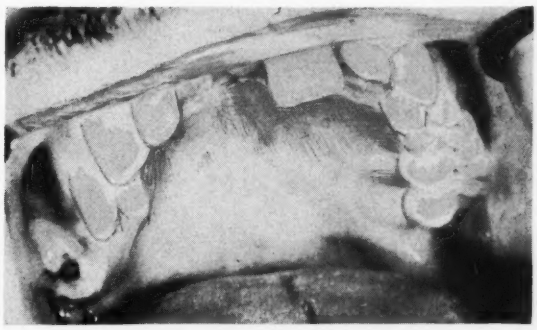
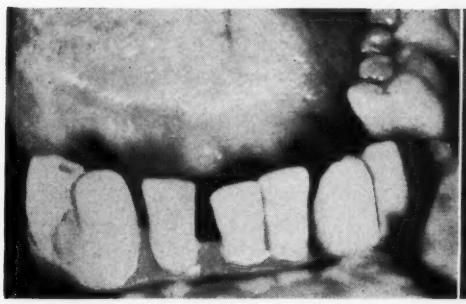


Fig. 1.



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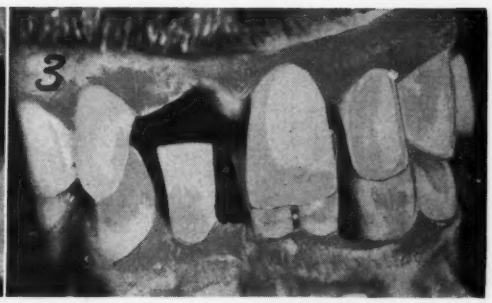

Fig. 3.

Figs. 1-3.—Before treatment.

cuspid and first molar, the lower left second bicuspid, the lower right central incisor, the lower right second bicuspid, and first and second molars were missing at the time of examination. His history revealed that these teeth were lost because of periodontal disease. The supporting bone of the remaining teeth was good, with the exception of the upper left bicuspid and lower left lateral incisor areas (Figs. 1 to 3).

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TREATMENT

Periodontal treatment was carried out with consideration of both the local and systemic aspects. The missing lower teeth with the exception of the central incisor were replaced with a cast partial denture, and the missing upper teeth were replaced with fixed restorations.

Fig. 4.

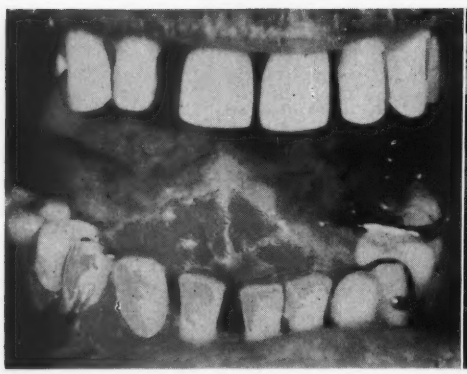

Fig. 5.

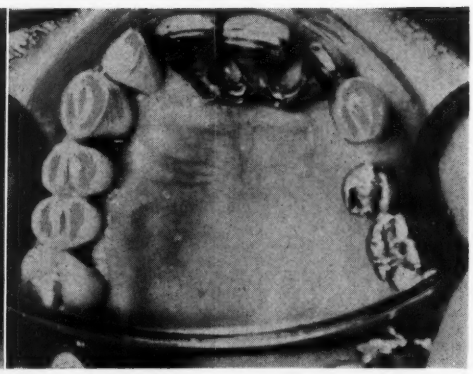

Fig. 6.

Figs. 4-6.—The completed restorations.

Three-quarter crowns with mesial and distal grooves and a pin in the cingulum were constructed on the upper right lateral and upper left central incisors. A Steele facing was used for the pontic, because of the deep vertical overlap. The backing for the pontic was cast with lingual arms extending to both three-quarter crowns. The pontic was properly positioned, and the lingual arms were soldered to the three-quarter crowns. Approximately one millimeter of space was allowed between the lingual arm and the tissue. The cast backing was made to cover the incisal edge of the Steele facing. The facing was glazed (Figs. 4 to 6).

CONCLUSIONS

In cases which require replacement of missing teeth where abnormally large interproximal spaces exist, it has been found that this technique is practical and economical. It provides excellent esthetic results as well as comfort, and seems to be superior to removable partial dentures which are so often constructed in similar cases.

Suite 417 Texarkana National Bank Building
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A PROSTHETIC CLOSURE OF A TRAUMATIC PALATAL PERFORATION

JOHN B. LAZZARI, D.D.S.

Bay Pines, Fla.

THIS REPORT of the procedure used to close, by means of a prosthetic appliance, a traumatic opening in the hard palate is not presented as a recommended technique. It is presented with the thought that a fellow practitioner who is faced with the same problem will gain some information from the method by which this particular appliance was constructed.

The patient was a well-developed, 27-year-old white man who was admitted to this hospital for a comminuted fracture of the ala and left innominate bone resulting from an automobile accident. Other than the hip injury his health was good, with a good blood picture and negative serology.

The perforation in the hard palate was secondary to admission diagnosis, and in itself had an interesting history (Fig. 1). It was the result of a gunshot wound from a 38-caliber pistol which occurred in 1948. The projectile entered the back near the left shoulder blade, passed upward into the mouth, thence through the roof of the mouth to exit at the right side of the nose near the eye. Other than the perforation in the hard palate, the results from this gunshot wound were negative. The perforation was ovoid in shape, 15 mm. in diameter, and opened directly into the nasal cavity. The patient had been unable to eat, drink, or smoke successfully or comfortably, and his speech had a resonance typical of cleft palate nasality. To compensate for this defect, he plugged the opening with a wad of chewing gum (one full pack) and managed fairly well, removing the chewing gum from the opening each night.

Clinically the examination of his mouth was negative. The tissues were normal and healthy, and the teeth in good position and occlusion. Radiographically the teeth were negative. Roentgenograms of the maxillae and of the head showed numerous small metallic fragments in the bones and soft tissues of the right side of the face, but there did not appear to be any metallic fragments in the region of the right orbit. There was no sinus involvement.

In preparation for the impression for this patient, the opening through the palate was carefully packed with a continuous strip of cotton. The last layer, or portion of the cotton exposed to the impression material, was coated lightly with petrolatum. This packing was carried to within 2 mm. of the margin of the opening on the palate. Impressions could be made without this packing, but the reproduction of the structures on the nasal side of the palatal opening

Received for publication May 20, 1952.

was not essential for appliance construction. The element of risk of the impression material breaking away and remaining in the nasal cavity, or packing around the septum, is an unnecessary one. A reversible hydrocolloid was used as the impression material.

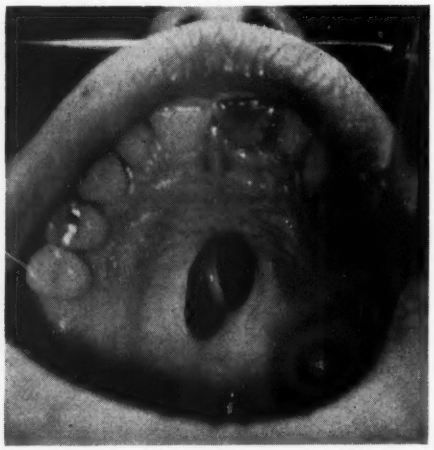
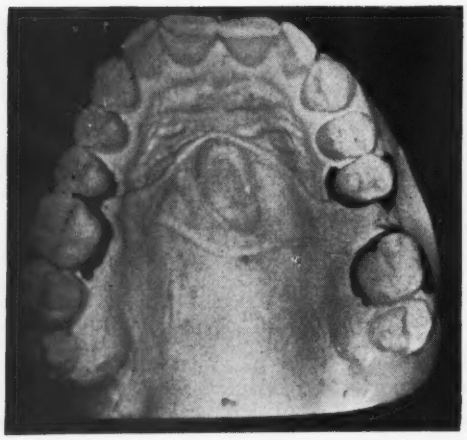


Fig. 1.—Gunshot wound in the palate.



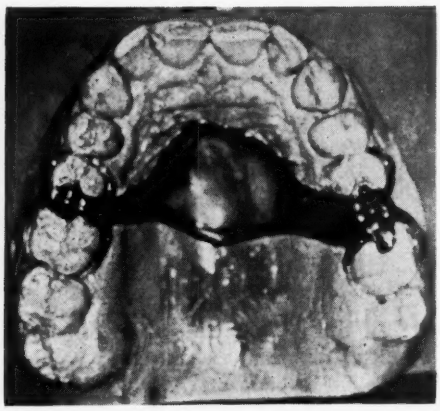


Fig. 2. Fig. 3.

Fig. 2.—The working cast prepared for duplication.
Fig. 3.—The wax pattern of the appliance on the refractory cast.

The steps in appliance construction were routine, much the same as employed in partial denture construction. The study cast was surveyed for retentive areas of the teeth to be clasped, and the design of the restoration was sketched on this cast. The teeth in the mouth were prepared in accordance with the study cast design, and the final impression was made. On the cast which recovered from the final impression, the peripheral relief of the design was placed. The teeth to be clasped were blocked out (Fig. 2), and the cast was duplicated in a refractory investment for the wax-up (Fig. 3) and casting of the appliance. The appliance was cast in gold (Fig. 4).

In the adaptation of the wax about the palatal opening, the wax-up was carried just beyond the lip of the opening, and not more than 1 mm. into the nasal cavity. This was the extent of the finished casting. No relief was made in or about this opening as it appeared on the cast. Regardless of the stability of the appliance when it is in position in the mouth, there would be a slight movement of it. If this area had been relieved, the movement would have caused an irritation about the palatal opening. If the slightest irritation caused by movement of the appliance movements appeared about the palatal opening, immediate and judicious adjustment of the appliance was indicated (Fig. 5).

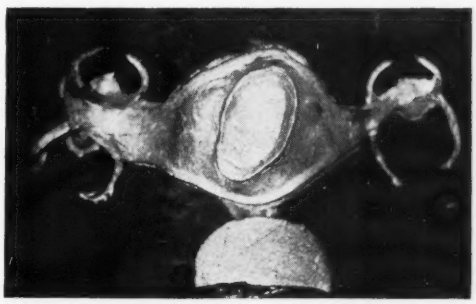


Fig. 4.—The palatal surface of the casting.

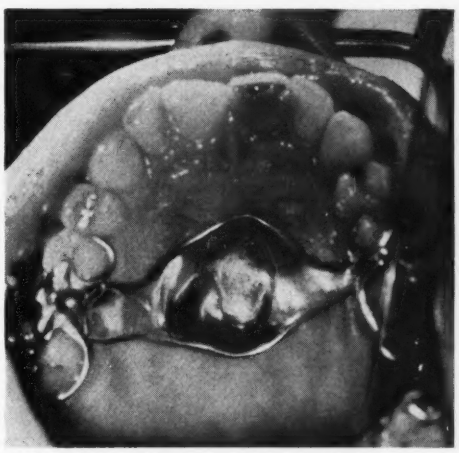


Fig. 5.—The completed restoration in place in the mouth.

SUMMARY

1. The construction of an appliance for closure of a traumatic palatal opening is similar to that of cast partial denture construction.

2. The opening in the palate should be packed to within 2 mm. of the palatal surface of the opening with a continuous cotton strip saturated with petrolatum.

3. No relief is made in or about the opening as it appears on the cast.

4. Guard against irritation about the palatal opening that may be caused by appliance movement.

Dental Service
Veterans Administration Center
Bay Pines, Fla.

HOW A SUCCESSFUL DENTAL CLINIC WAS FORMED AND HOW IT FUNCTIONS TODAY

JAMES L. ARMSTRONG, D.D.S.

Miami, Fla.

THE VITAL needs for postgraduate dental education and training and for top-notch dental care for the poor provided the combined stimulus for founding of the Dade County Dental Research Clinic in Miami, Fla. Three interdependent factors, the determination of a progressive group of dentists, the cooperation of a school board and county commission, and the crying need for dental care of the indigent, led finally to its success. Now five years old, the clinic daily fills a larger and larger niche in the community. Already it is an organization of continuing progressive dental advancement, of educational goals yet to be attained.

Still unique in the nation, as it was when it first opened its doors in February, 1947, the clinic is now so successful that an article dealing with its origin and organization may be of value to other sections of the country anxious to begin a similar setup. Certainly, we at the clinic believe it would be of tremendous benefit both to the profession and to the public if similar clinics were spotted throughout the nation.

For the dentists, the clinic now provides a teaching program, including many of the newest dental developments. For charity patients, it means dental care by members of the organization.

In the beginning, sixty Miami dentists, all members of the Florida East Coast Dental Society, combined to support the establishment of the clinic. They all were imbued with the idea of doing a better job for dentistry, and at the same time doing as much as possible for the poor. This was the plan from the dental standpoint.

An additional plan included the training of dental assistants. Thus, the logical location for such a clinic was in Dade County's Vocational High School where dental assistant trainees could be drawn from the student body.

When approached on the matter, Dade County's School Board endorsed the entire program 100 per cent. Not only did the school officials offer space, but they also agreed to renovate quarters for the clinic.

From that time on the clinic was no longer a theory, but was a growing organization, bringing knowledge of better dentistry to its members and administering excellent dental attention to indigent patients of Dade County.

Received for publication July 24, 1952.

PHYSICAL SETUP

The dentists are divided into the following groups: 1) Amalgam and porcelain restoration; (2) fixed and removable bridges; (3) gold inlays; (4) periodontia; (5) prosthetics; (6) orthodontia; (7) oral surgery, and (8) x-ray and diagnosis. There also is a group for dental hygienists. The sections are each made up of ten men, and a chairman is selected to direct the work in each particular field.

Dentists in each group attend the clinic one full day a month for one school year; at the end of that time they rotate to another group (except in orthodontia where there is no rotation), and so on through the years until everyone has worked in every classification.

Nine dental units, two x-ray machines, a large laboratory, and a reception room are contained in the clinic itself.

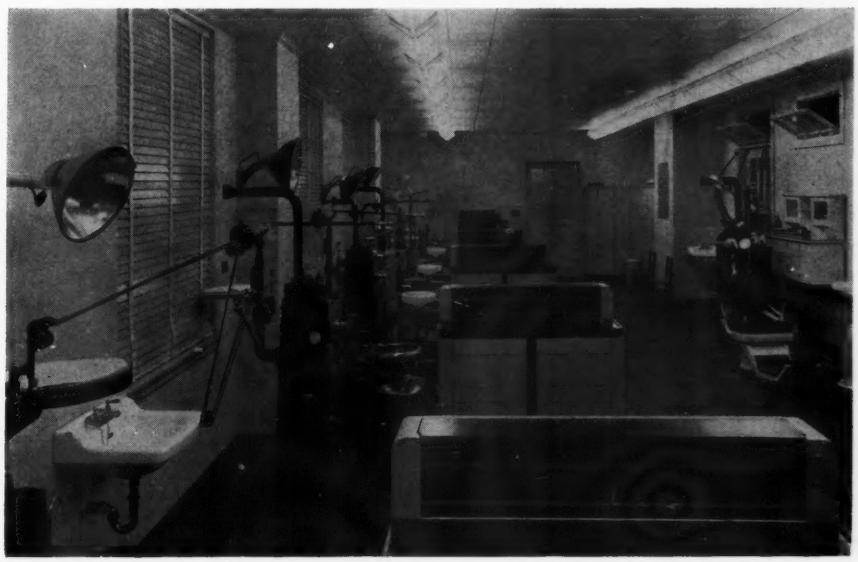


Fig. 1.

Dental assistants for the project are trained both in the clinic and in the classrooms. Instruction has been combined into a three-year course designed to turn out skilled students thoroughly trained in dental procedures. Since these trainees are of high school age, the more serious and settled girls are selected for this particular course.

The first two years of the training covers not only regular required high school subjects, but also the necessary dental information on theory and office routine. This includes a comprehensive course of shorthand, typing and bookkeeping. Also included in this basic instruction are such subjects as general health, histology, elements of dental anatomy, dental prosthetics, sterilization, x-ray development, etc.

The final year is spent in the clinic where students receive practical training. In this connection, students taking their last term of schooling are sent

part time to individual members' private offices for internships from March to June. Thus, on graduation, assistants will be both experienced and trained.

Patients are admitted for treatment only after they are cleared and certified by the Dade County Welfare Board. Each individual is then given a complete dental diagnosis and treated by each group as thoroughly as their needs demand.

During the year 1951-1952 a total of 2,752 adult patients were so cared for.

Financial Arrangements.—The Dade County Commission and the Dade County School Board have assumed the financial and educational responsibilities of the clinic. The County Commission allocates $1,000.00 per month for supplies, laboratory fees, etc. The school board retains a graduate dentist as a full-time instructor for the assistants and as the clinic director. There is also a clinic supervisor.

SUMMARY

The following suggestions may prove helpful in establishing clinics elsewhere:

1. Call a meeting of local dentists for discussion of a clinic and future plans. Then, if interest warrants, elect temporary officers. Secure reprints of this article and furnish copies to the vocational school authorities and city or county officials in order to familiarize them with the project you are about to present. Make a small assessment for organizational expense.

2. Follow an orderly plan. Nothing is so fatal to a new organization as too many meetings.

3. Work out a cost estimate of the clinic's plumbing and other necessary installations. Cost of equipment, instruments, and supplies should be known before presenting the project to school or city authorities.

4. If after discussion school authorities show interest, suggest they write Lindsey Hopkins Vocational School here for further details as to the clinic's operation, and to see if it fits into their particular vocational school program.

5. If favorably accepted by the school board, then appear before city or county officials in order to obtain the financial aid necessary to found and support the clinic.

For further information write:

The Dade County Dental Research Clinic
Lindsey Hopkins Vocational School
1410 N. E. Second Avenue
Miami, Fla.

9528 N. E. Second Avenue
Miami, Fla.

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2. All essays are to be on some phase of prosthetic dentistry.
3. All essays are to become the property of the American Denture Society, and none will be returned.
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5. Essays must be double spaced, on plain paper with generous margins. No carbon copies or essays on onion skin paper will be considered.
6. Illustrations must conform to the standards of the JOURNAL OF PROSTHETIC DENTISTRY.
7. The essay must be worthy of publication in the JOURNAL OF PROSTHETIC DENTISTRY to qualify for the prize.
8. Essays must be postmarked by July 1, 1953, in order to receive consideration.
9. The Judges are a special committee of the American Denture Society.
10. The decision of the judges is final.
11. All essays are to be clearly marked as contest papers and sent to:

Dr. Carl O. Boucher, College of Dentistry, Ohio State University,

Columbus 10, Ohio

All contest papers will be sent by him to the committee judging the contest.

News and Notes

ANNOUNCEMENTS

The meeting of The American Denture Society will be held Feb. 7 and 8, 1953, at the Congress Hotel in Chicago, Ill.

The meeting of the American Academy of Restorative Dentistry will be held Feb. 7 and 8, 1953, at the Conrad Hilton Hotel in Chicago, Ill.

The Twenty-eighth Annual Greater New York Dental Meeting will be held on Dec. 8-11, 1952, at the Hotel Statler, New York, N. Y.

The American Board of Prosthodontics will hold its next examination at the School of Dentistry, University of Indiana, 1121 West Michigan Street, Indianapolis 2, Ind., Feb. 1-7, 1953. For further information write to Dr. Irving R. Hardy, Tufts College Dental School, Boston, Mass.

The Twenty-first Annual Postgraduate Clinic of the District of Columbia Dental Society will be held March 15-18, 1953, at the Shoreham Hotel, Washington, D.C. The General Chairman is Dr. Z. Bernard Lloyd, 2007 R Street, N. W., Washington, D. C. Further information can be obtained by writing to Edward H. Steinberg, Executive Secretary, 1835 Eye Street, N. W., Washington 6, D. C.

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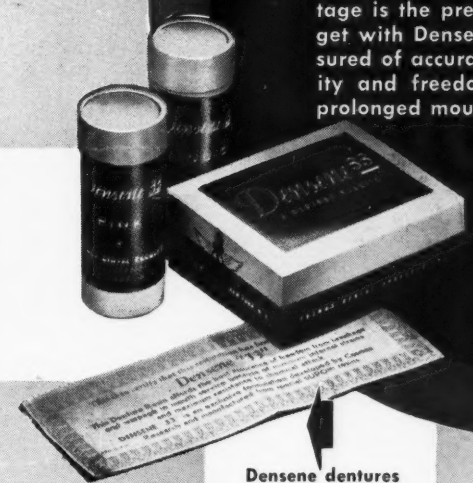

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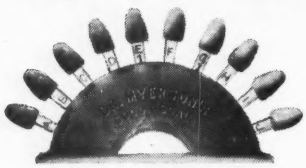

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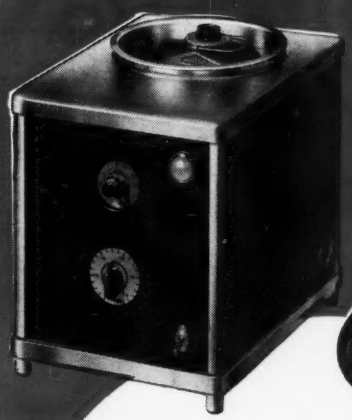

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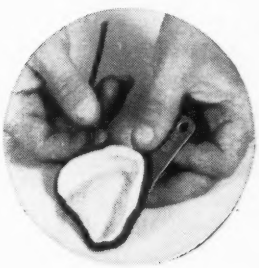

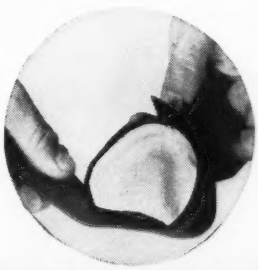

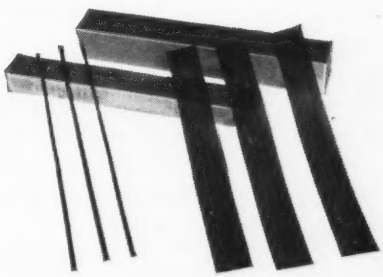

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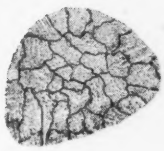
F FOR FINE-GRAIN STRUCTURE . . . 

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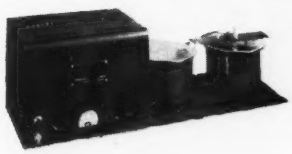
T TI-LECTRO POLISHED . . . 

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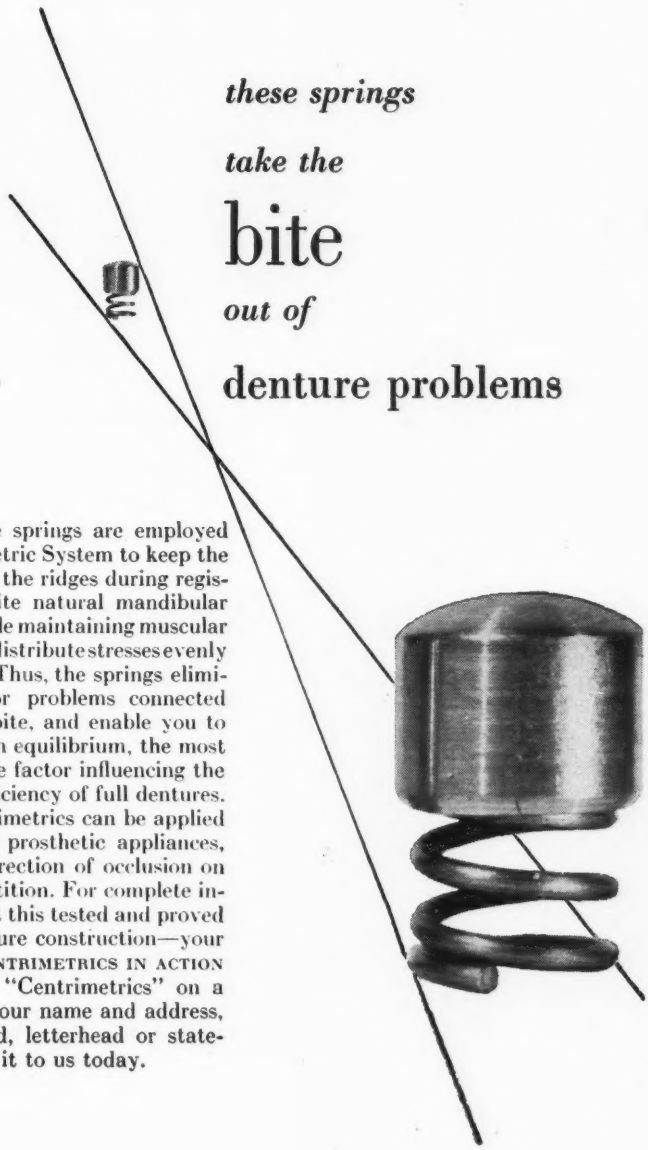

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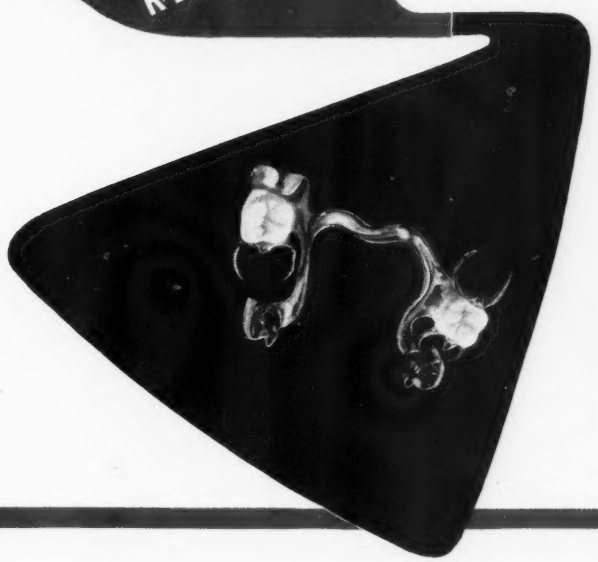

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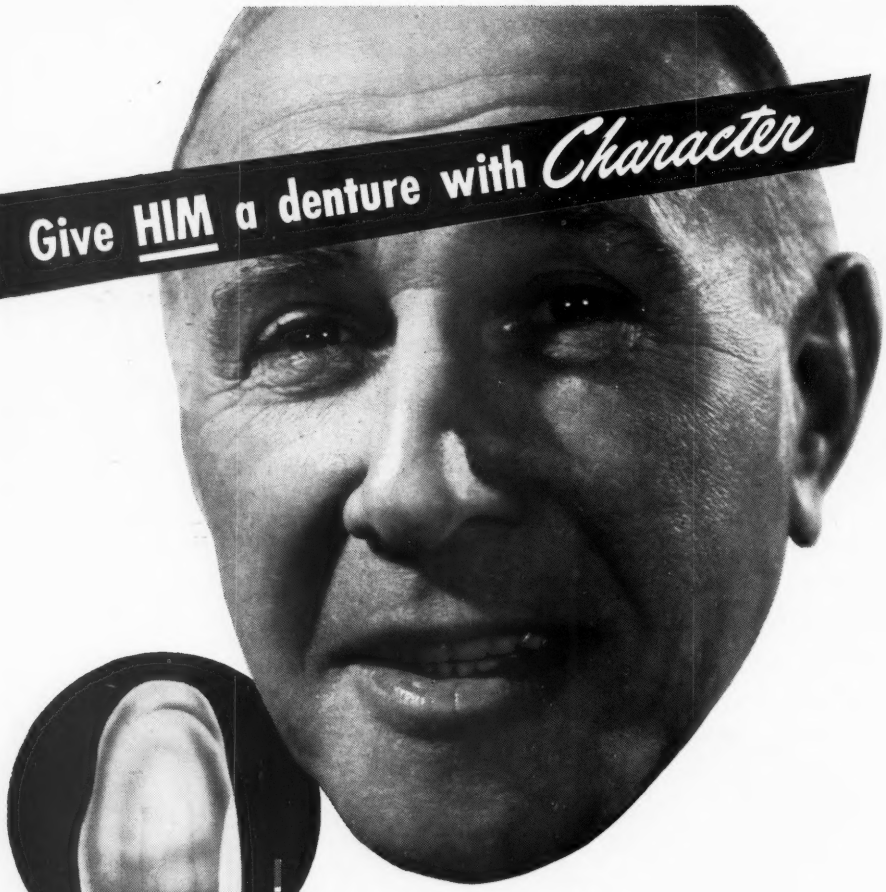

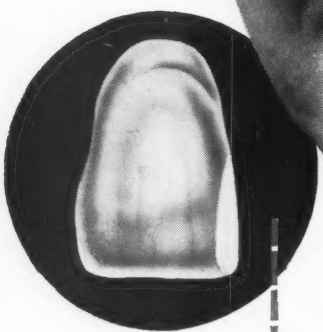

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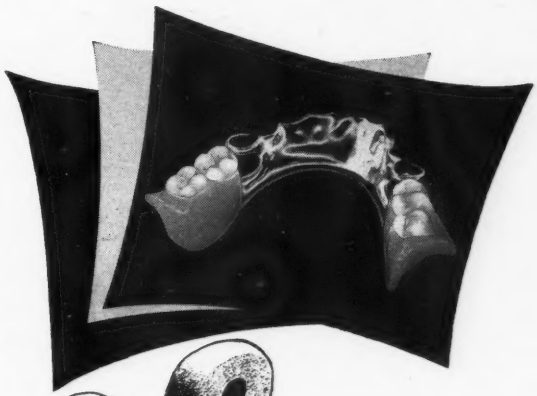

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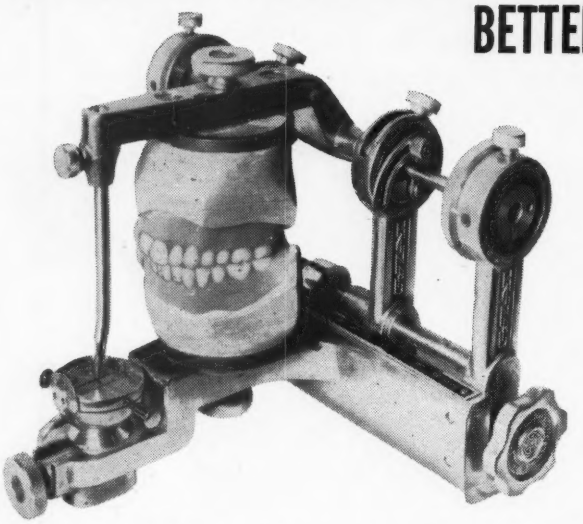

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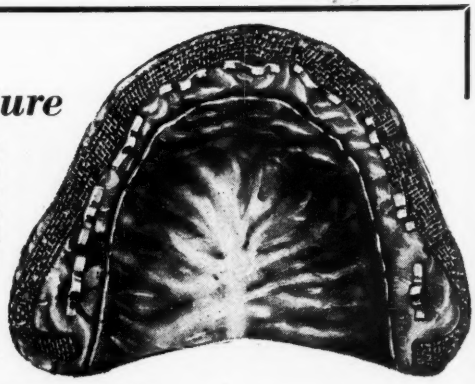

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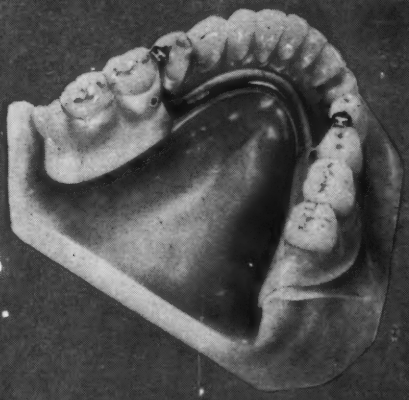

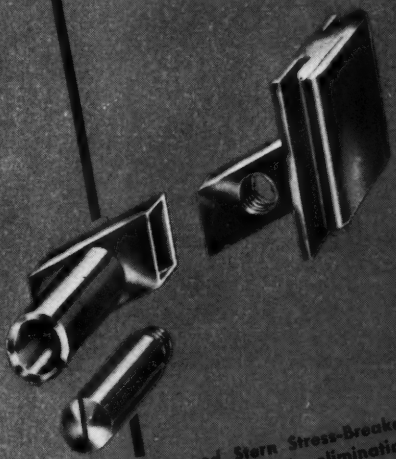

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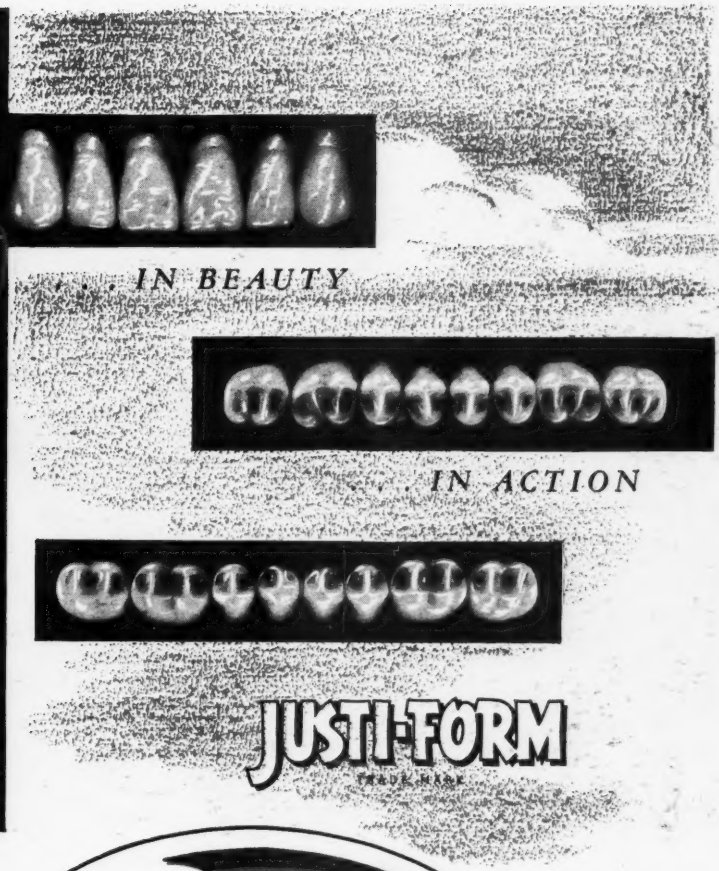
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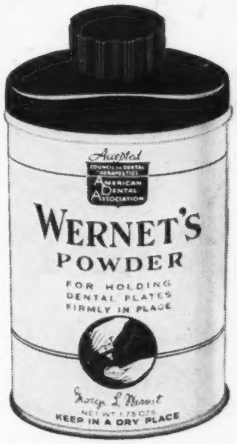

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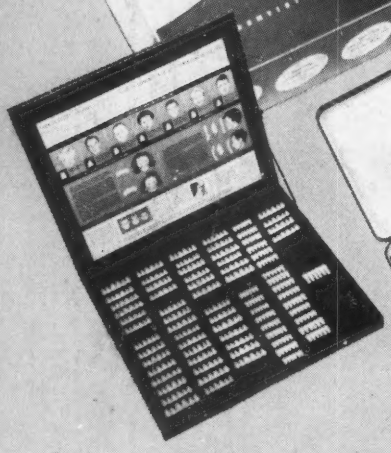

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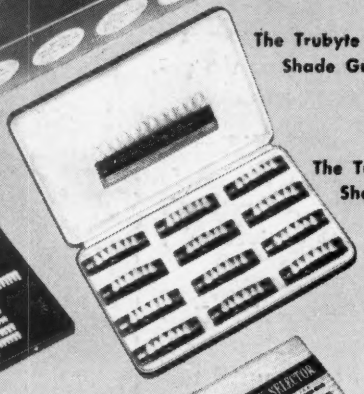

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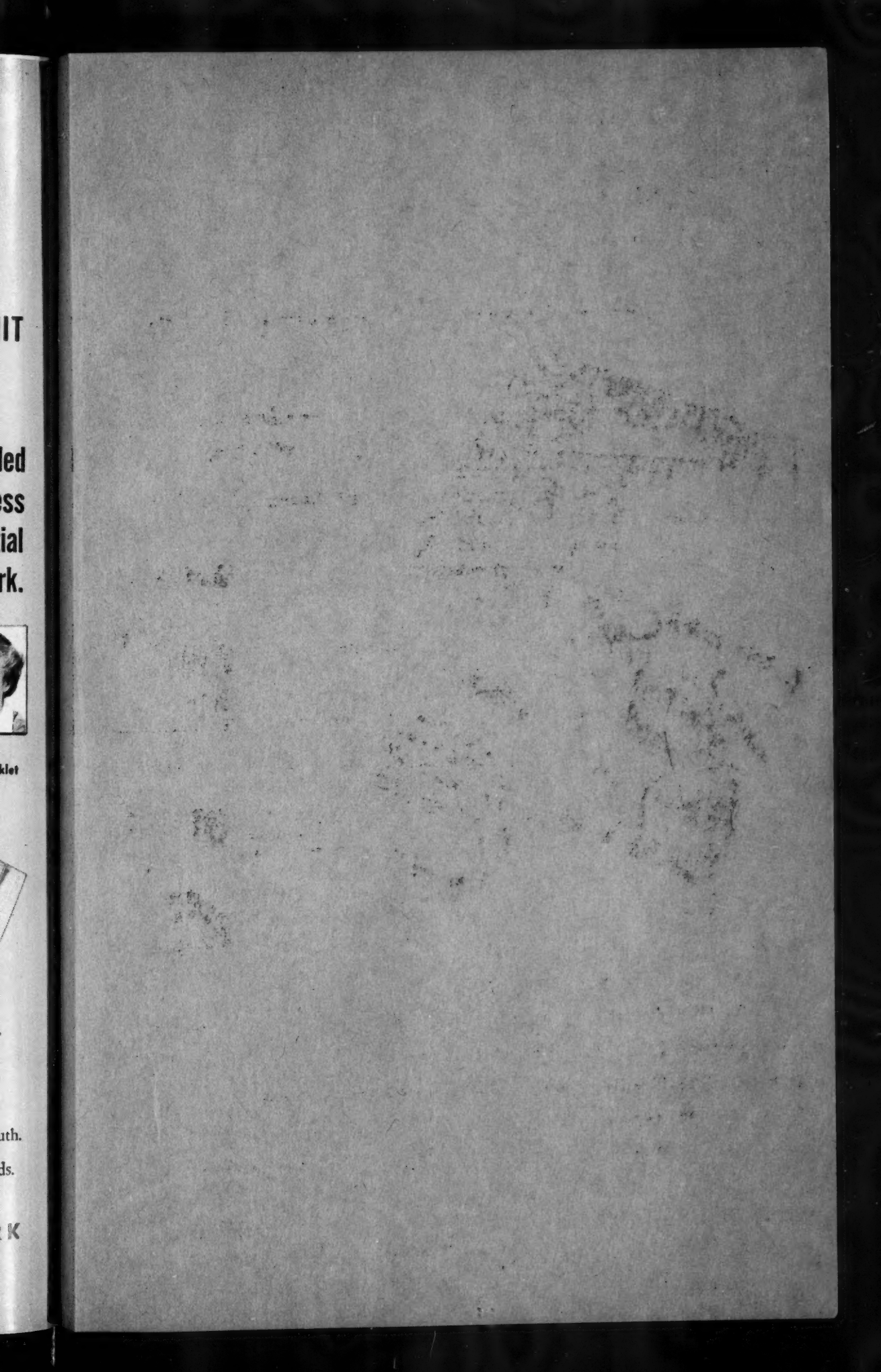
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